RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 60:

Reference(s): Exhibit 2B, Section A6, p. 33
Chapter 2 Appendices, Appendix 2-AA

Preamble:
Toronto Hydro provided the following summary table with respect to its historical and proposed capital expenditures for the 2015-2024 period.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Access</td>
<td>58.3</td>
<td>79.0</td>
<td>65.5</td>
<td>100.8</td>
<td>97.1</td>
<td>91.8</td>
<td>93.3</td>
<td>93.9</td>
<td>106.0</td>
<td>116.4</td>
</tr>
<tr>
<td>System Renewal</td>
<td>304.1</td>
<td>266.1</td>
<td>250.3</td>
<td>299.4</td>
<td>253.4</td>
<td>306.6</td>
<td>325.7</td>
<td>323.1</td>
<td>339.0</td>
<td>325.5</td>
</tr>
<tr>
<td>System Service</td>
<td>37.9</td>
<td>53.3</td>
<td>72.4</td>
<td>41.4</td>
<td>41.8</td>
<td>34.2</td>
<td>60.1</td>
<td>71.3</td>
<td>33.6</td>
<td>38.5</td>
</tr>
<tr>
<td>General Plant</td>
<td>79.4</td>
<td>109.5</td>
<td>98.9</td>
<td>70.0</td>
<td>40.2</td>
<td>78.8</td>
<td>93.7</td>
<td>89.0</td>
<td>77.7</td>
<td>85.2</td>
</tr>
<tr>
<td>Other</td>
<td>11.6</td>
<td>3.7</td>
<td>10.7</td>
<td>6.3</td>
<td>2.4</td>
<td>7.0</td>
<td>9.0</td>
<td>9.8</td>
<td>9.5</td>
<td>8.7</td>
</tr>
<tr>
<td>Total Capex</td>
<td>491.4</td>
<td>511.6</td>
<td>497.8</td>
<td>447.8</td>
<td>434.9</td>
<td>518.4</td>
<td>581.8</td>
<td>587.1</td>
<td>565.7</td>
<td>574.4</td>
</tr>
<tr>
<td>System O&amp;M</td>
<td>116.1</td>
<td>126.5</td>
<td>126.3</td>
<td>126.9</td>
<td>131.0</td>
<td>130.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a) For the forecast period (2020-2024), at the same level of detail as Appendix 2-AB, please provide the proposed capital in-service additions.

b) For the forecast period (2020-2024), at the capital program level similar to Appendix 2-AA, please provide the following:
   i) The gross capital expenditures, the associated capital or customer contributions (as appropriate) and the net capital expenditures.
ii) The gross capital in-service additions, the associated capital or customer contributions (as appropriate) and the net capital in-service additions.

c) Please confirm that Toronto Hydro is seeking approval of the capital in-service amounts provided in response to part (a) of this question.

d) Please advise whether Toronto Hydro would be willing to file with the OEB an annual status update with respect to its capital expenditures and capital in-service additions.

e) Please advise whether Toronto Hydro expects to update the capital expenditure (and in-service addition) proposals set out in its DSP at the time of its application update to reflect the most recent forecasts of the capital work that will be completed during the 2015-2019 period.

**RESPONSE:**

a) Toronto Hydro does not have a forecast of in-service additions at the program level, and is unable to create the information requested in the time provided for interrogatory responses. Please see response to interrogatory 2A-SEC-31 on the limitations of such a forecast.

b)

i) The following table provides the gross capital expenditures, capital contribution, and net capital expenditures for programs that have capital contributions:
Table 1: Programs with Capital Contributions Cost Breakdown ($ Millions)

<table>
<thead>
<tr>
<th>Programs ($M)</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIFRS</td>
<td>MIFRS</td>
<td>MIFRS</td>
<td>MIFRS</td>
<td>MIFRS</td>
</tr>
<tr>
<td>Customer Connections - Gross</td>
<td>76.5</td>
<td>78.8</td>
<td>80.0</td>
<td>82.3</td>
<td>84.1</td>
</tr>
<tr>
<td>Customer Connections - CC</td>
<td>(33.7)</td>
<td>(34.9)</td>
<td>(35.2)</td>
<td>(36.7)</td>
<td>(37.8)</td>
</tr>
<tr>
<td>Customer Connections - Net</td>
<td>42.9</td>
<td>43.9</td>
<td>44.8</td>
<td>45.6</td>
<td>46.3</td>
</tr>
<tr>
<td>Externally Initiated Plant Relocations &amp; Expansion - Gross</td>
<td>46.3</td>
<td>82.3</td>
<td>56.9</td>
<td>55.8</td>
<td>57.6</td>
</tr>
<tr>
<td>Externally Initiated Plant Relocations &amp; Expansion - CC</td>
<td>(34.9)</td>
<td>(61.4)</td>
<td>(52.2)</td>
<td>(51.1)</td>
<td>(53.0)</td>
</tr>
<tr>
<td>Externally Initiated Plant Relocations &amp; Expansion - Net</td>
<td>11.4</td>
<td>20.8</td>
<td>4.6</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Energy Storage Systems - Gross</td>
<td>25.3</td>
<td>15.8</td>
<td>9.6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Energy Storage Systems - CC</td>
<td>(24.3)</td>
<td>(12.1)</td>
<td>(5.6)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Energy Storage Systems - Net</td>
<td>1.0</td>
<td>3.7</td>
<td>3.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

ii) Please see response to part (a).

c) Toronto Hydro is seeking approval for the rates that are derived from the capital related revenue requirement (“CRRR”) of the proposed capital program. The in-service capital forecasts provided in interrogatory response 1B-Staff-22 Appendix A form the basis of the CRRR.

d) Toronto Hydro proposes to continue report on its DSP Implementation Progress on annual basis as part of the Electricity Distributor Scorecard (see Exhibit 1B, Tab 2, Schedule 4, Appendix A). Reporting on capital expenditures provides the clearest view of Toronto Hydro’s progress in implementing its capital plan, which is prepared through business planning and presented in this Application on the basis of capital expenditures. Toronto Hydro would need to understand the intended purpose of reporting on the in-service additions of capital assets in order to evaluate such a proposal.

e) Toronto Hydro is still evaluating whether any 2019 financial forecasts from the Application and pre-filed evidence will need to be updated as part of the 2018 financial update.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 61:
Reference(s): Exhibit 2B, Section A4.1.3, p. 16

Preamble:
Toronto Hydro stated:

“Another relevant aspect of economic growth in the City of Toronto is the number
of large, third-party infrastructure renewal and expansion projects that require
Toronto Hydro to relocate its existing infrastructure. Toronto Hydro is obligated by
the Public Service Works on Highway Act (“PSWHA”) and section 3.4 of the
Distribution System Code (“DSC”) to accommodate these third-party requests in a
fair and reasonable manner. For the 2020-2024 period, the utility is expecting
greater needs in this area due to a larger number of committed relocation and
expansion projects by Metrolinx, the Toronto Transit Commission, and the City of
Toronto.” (Exhibit 2B / Section A4.1.3 / p. 16)

a) Please advise whether Toronto Hydro had the same expectation in the 2015-2019
DSP and explain whether the expected level of incremental relocation work was
required on an actual basis. If not, please explain why Toronto Hydro believes that
a greater amount of relocation work will be required over the 2020-2024 period.

RESPONSE:
a) Please refer to Exhibit 2B, Section E5.2.4, page 7, lines 21-23 and page 8, lines 1-19 for
Toronto Hydro’s expectations that formed the basis of the 2015-2019 Externally
Initiated Plant Relocations and Expansion forecast, the work executed (and expected
to be executed) over that period, its associated costs, and the rationale behind the
greater amount of relocation work expected over the 2020-2024 period.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 62:
Reference(s): Exhibit 2B, Section A4.4, pp. 22-23

Preamble:
Toronto Hydro lists the following sources of cost savings resulting from its capital programs: Grid Modernization; Capacity Improvements; Standardization; Area Rebuilds; Conservation First; Safety and Environmental Costs; Enhanced Work Coordination; Facilities Asset Management System; and Procurement (Exhibit 2B / Section A4.4 / pp. 22-23).

a) Please provide estimated cost savings attributed to each of the above categories and explain how these savings will be monitored over the 2020-2024 period.

RESPONSE:
Please see Toronto Hydro’s response to interrogatory 1B-CCC-14.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 63:

Reference(s): Exhibit 2B, Section B, Appendix C, p. 34

a) Please update section 7.1.3 (Recommended Plan and Current Status) (Exhibit 2B / Section B / Appendix C / p. 34) with updated information and explain how the details from the provided update have been incorporated into the proposed DSP.

RESPONSE:

a) There has been no change to the Recommended Plan. Please refer to Exhibit 2B, Sections E5.2 and E7.4 for work planned in alignment with system needs identified in the Regional Infrastructure Plan.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 64:
Reference(s): Exhibit 2B, Section B, Appendix E, pp. 36-38

Preamble:
The technical assessment of the electricity system serving Central Toronto uncovered a number of system needs to be addressed by actions in the near term and medium term. The near-term needs (0 to 5 years) and the medium-term needs (6 to 10 years), and the options and recommended actions for addressing these needs are summarized in Table 6-1 (Exhibit 2B / Section B / Appendix E / p. 37).

a) Please provide any updates to Table 6-1 (Exhibit 2B / Section B / Appendix E / p. 37) based on the most recent available information.

RESPONSE:
a) Exhibit 2B, Section B, Appendix E is the Integrated Regional Resource Plan (IRRP) led by the IESO, which was completed in April 2015. Following the IRRP, updates to the needs summarized in Table 6-1 were published in the Regional Infrastructure Plan in January 2016 (led by Hydro One) and in the new Needs Assessment report in October 2017 (led by Hydro One). Please refer to Exhibit 2B, Section B, Appendix C and Appendix A, respectively. These updates are provided below.

“Breaker failure contingency at Manby West and Manby East”: Hydro One is in the process of designing and installing a Remedial Action Scheme at Manby West and Manby East for service early in 2019.
“Breaker failure contingency at Leaside TS”: This need was updated in the Regional Infrastructure Plan where it was identified that no additional investment was recommended as the issue was mitigated by the new normally open switch installed at Bridgman TS. Please refer to Exhibit 2B, Section B, Appendix C, Section 7.7.

“Demand growth in West Toronto is forecast to exceed the limits of Runnymede TS and Fairbank TS”: There are no changes to the recommended actions for this need. Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-63.

“Demand growth in Southwest Toronto is forecast to exceed the limits of Manby TS and Horner TS”: There are no changes to the recommended actions for this need. Please refer to Exhibit 2B, Section E7.4.4.2 for more details.

“Demand Growth in Central Toronto is forecast to exceed the limits of the 230kV Richview TS to Manby TS corridor”: This need was updated in the Needs Assessment report (October 2017) to outline station work in addition to the original line project. Please refer to Exhibit 2B, Section B, Appendix A, Section 7.2.3.

“Demand growth in the downtown core is forecast to exceed the limits of Esplanade TS and Copeland TS”: This need was reaffirmed in the Needs Assessment report (October 2017). Please refer to Exhibit 2B, Section B, Appendix A, Section 7.2.2. The report recommended that the need and timing for Phase 2 of Copeland TS be further refined by Toronto Hydro through their distribution planning processes. Please refer to Exhibit 2B, Section E7.4.4.1 for details of the proposed Copeland TS – Phase 2 project.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 65:

Reference(s): Exhibit 1B, Tab 2, Schedule 1, p. 7
Exhibit 2B, Section C2, pp. 5-7, 22-23
Exhibit 1B, Tab 2, Schedule 1, Appendix B, p. 17

Preamble:
Toronto Hydro provided a list of 15 custom performance measures (incremental to the 29
generic measures) to be reported to the OEB annually. The targets for the metrics are
described as either improve or monitor.

Toronto Hydro notes that if the approvals differ from those sought in the application it
will need to reassess the forecasted attainable performance related to the custom
metrics (Exhibit 2B / Section C2 / pp. 4-5).

a) Please confirm that Toronto Hydro is seeking approval of the custom performance
measures (Exhibit 2B / Section C2 / p. 5).

b) If the revenue requirement-related approvals differ from those sought in the
application, please advise whether Toronto Hydro intends to update the targets
for the custom performance measures at the draft rate order stage of the
proceeding (Exhibit 2B / Section C2 / p. 5). Alternatively, please explain whether
Toronto Hydro would consider establishing targets with bandwidths to
accommodate risks outside the utility’s control.
c) Please advise whether Toronto Hydro considered whether it would be appropriate to apply incentives / penalties for achieving / underperforming relative to the targets (only those targets that are described as improve).

d) Please provide Toronto Hydro’s position on presenting the metrics, which are currently titled “improve”, as an actual numerical target as opposed to a directional target. Please discuss for which measures there is an established numerical target (and provide the target). For those where there is no established numerical target, please explain how improvement will be measured and explain why no numerical target can be established.

e) With respect to the e-billing measure (Exhibit 2B / Section C2 / p. 7), please advise whether the correct understanding is that Toronto Hydro will have succeeded on this measure if it manages to have a total of 347,000 customers on e-billing by 2024.

f) With respect to the average wood pole replacement cost measure (Exhibit 2B / Section C2 / p. 22), please explain why there is no baseline cost to use for this measure in the context of the information contained in the unit cost benchmarking study (Exhibit 1B / Tab 2 / Schedule 1 / Appendix B / p. 17).

g) With respect to the vegetation management cost per km measure (Exhibit 2B / Section C2 / p. 23), please explain why there is no baseline cost to use for this measure in the context of the information contained in the unit cost benchmarking study (Exhibit 1B / Tab 2 / Schedule 1 / Appendix B / p. 17).
RESPONSE:

a) Toronto Hydro is seeking approval to include any custom measures along with its annual performance scorecard reporting obligation to the OEB, however it is not seeking approval of its specific custom measures, the definition of those measures or the targets for those measures (as applicable).

b) Toronto Hydro’s custom performance measures and targets have been developed on the basis of the proposals, plans, and resulting revenue requirement included in the application. To the extent that the approvals differ from those Toronto Hydro seeks in the application, the utility would need to reforecast and re-assess its forecasted attainable performance for the period. Toronto Hydro is unsure about the timelines that would be required for such an activity as they depend on the ultimate decision by the OEB in this Application. However, it would begin work on this effort immediately following the completion of the draft rater order process and would provide reporting on its measures for all years of the plan term (2020 through 2024). As part of this process, Toronto Hydro would consider establishing targets with bandwidths to accommodate for risks beyond its control.

c) Toronto Hydro does not believe that the application of incentives or penalties is appropriate at this time, given the relative maturity of regulatory policy on this topic as well as its proposed outcomes framework as well as this concept. This Application is the first such rate filing by Toronto Hydro that includes its proposed outcomes framework and 15 associated custom measures. Because this framework and these measures are being established for the first time, there is no associated history that would enable a reference as to what the target level should be for purposes of incentives or penalties. Moreover, as noted in part (b) above, there is an inextricable link between approvals for funding through rates and the capacity of the utility to
achieve outcomes. Incentives or penalties would need to be calibrated to account for that, and there is currently no regulatory framework for such a calibration.

d) Please refer to Toronto Hydro’s response to interrogatory 2B-VECC-11.

e) Subject to the risks outside of Toronto Hydro’s control, the understanding as stated is correct. Please refer to Exhibit 2B, Section C2, page 5.

f) Please refer to Toronto Hydro’s response to interrogatory 2B-PWU-3.

g) Please see response to part (f).
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 66:

Reference(s): Exhibit 2B, Section D2, p. 12

a) Please explain how the amounts included in Table 1 (Exhibit 2B / Section D2 / p. 12) were calculated.

RESPONSE:

a) Table 1 below outlines how each of the AM Performance Indicators were derived.

Table 1: Derivation of AM Performance Indicators

<table>
<thead>
<tr>
<th>AM Performance Indicators</th>
<th>Derivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Deficiencies</td>
<td>The number of assets with an oil leak identified during inspections were aggregated for each system category.</td>
</tr>
<tr>
<td>Priority Deficiencies</td>
<td>The number of deficiencies with work requests issued and priorities (i.e. P1, P2, P3) assigned were grouped into the four system categories.</td>
</tr>
<tr>
<td>Customer Hours of Interruption</td>
<td>Defective Equipment outage incidents were grouped into the four system categories and the corresponding total number of customer hours interrupted was summed.</td>
</tr>
<tr>
<td>Customer Interruptions</td>
<td>Defective Equipment outage incidents were grouped into the four system categories and the corresponding total number of customers interrupted was summed.</td>
</tr>
<tr>
<td>Condition</td>
<td>Calculated based on the number of assets in HI4 or HI5 divided by the total population of the assets with health scores in each system category.</td>
</tr>
<tr>
<td>Oil Containing PCBs</td>
<td>The number of assets containing or at-risk of containing PCBs were aggregated for each system category.</td>
</tr>
<tr>
<td>Age</td>
<td>The number of assets that are at or past Useful Life for each system category.</td>
</tr>
<tr>
<td>Legacy Assets</td>
<td>The remaining inventory of the asset or configuration type in the distribution system.</td>
</tr>
</tbody>
</table>
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 67:

Reference(s): Exhibit 2B, Section D3, pp. 4, 11, 13-14, 22-24, 30, 47

a) Regarding the planned maintenance activities (Exhibit 2B / Section D3 / p. 4), please explain how the cycles (number of years) were established.

b) Regarding the repair of failed or defective equipment (Exhibit 2B / Section D3 / p. 11), please explain how these costs are treated (capital or OM&A) and provide the total cost of these types of repairs over the 2015-2019 period.

c) With respect to overhead switches (Exhibit 2B / Section D3 / p. 13), please explain why Toronto Hydro does not have a dedicated proactive renewal strategy for this class of asset.

d) With respect to overhead conductors (Exhibit 2B / Section D3 / p. 14), please explain why Toronto Hydro does not have a dedicated proactive renewal strategy for this class of asset.

e) Please explain how asset condition assessment, predictive failure modelling, historical reliability analysis and economic risk-based analysis interact in terms of determining how to direct capital expenditures.

f) Please advise whether a scope of work document is produced for every project or only for major projects. Please provide a sample scope of work document (Exhibit 2B / Section D3 / p. 47).
RESPONSE:

a) As noted in Exhibit 2B, Section D3, pages 2-3, the foundation of Toronto Hydro’s maintenance plans, including the specific maintenance activities and their associated cycles are Reliability Centered Maintenance (“RCM”) analyses. The analyses answer a series of related questions with respect to assets and their components. These questions focus on (i) component functions, (ii) functional failures, (iii) failure modes, (iv) failure effects, (v) failure consequences, and (vi) maintenance tasks (and their cycles) that should be undertaken to predict or prevent failures. The answers to one question influence the answers to subsequent questions.

With respect to question (vi), the determination for each maintenance task is made by considering responses to previous questions (i.e. i – v) and factors such as mean time to failure, potential to functional failure (often referred to as p-to-f) intervals, and the cost of maintenance relative to replacement at the time of failure. Those determinations also consider other factors such as minimum inspection requirements pursuant to the Distribution System Code. The outputs from the RCM analyses form the set of recommended maintenance tasks, and the cycles that are contained in Table 1 of Exhibit 2B, Section D3.

Please note that not all maintenance activities and cycles in Table 1 are set using RCM analyses. Below is a list of notable exceptions together with a brief description of how associated cycles were established:

- **Tree Trimming**: As described in Exhibit 4A, Tab 2, Schedule 1, page 29, feeders are trimmed on a variable cycle of two to five years based on assessments of tree pruning needs that consider criteria such as feeder reliability history,
number of customers supplied by each feeder, and the amount of time that
has elapsed since the trees surrounding the feeder were last pruned.

• **Insulator Washing**: Only locations at a high risk of accumulating
  contamination (predominantly from road de-icing materials that become
  airborne and attach to insulators) are washed twice a year as described in
  Exhibit 4A, Tab 2, Schedule 1, beginning on page 22. These high risk locations
  are fewer than 5% of Toronto Hydro’s wood pole locations and they are
  washed once prior to the use of de-icing salts and brines on roadways (i.e. in
  Fall) and once after (i.e. in the Spring).

• **Contact Voltage**: As described in Exhibit 4A, Tab 2, Schedule 2, page 32,
  contact voltage causes include the freeze/thaw cycle and as a result, scanning
  is planned on an annual cycle to monitor conditions during and following
  winter months.

b) **Costs associated with repair and refurbishment of failed or defective equipment**
   would be treated as capital with a few exceptions (e.g. assets do not go into service, repairs
   were unsuccessful). For further context, failed or defective equipment is taken out of
   service, salvaged (if repair or refurbishment is feasible), and returned to the
   manufacturer (or third party) to be repaired or refurbished. Repaired or refurbished
   equipment is then used as part of capital projects.

   Toronto Hydro estimates direct repairs and refurbishments (e.g. transformers) will cost
   approximately $1 million over the 2015-2019 period. Savings associated with repairs
   and refurbishments are estimated to exceed $5 million over the same period.
c) Asset classes or types for which Toronto Hydro does not have a “dedicated proactive renewal strategy” are ones that are (along with their associated risks) capable of being managed as part of a broader strategy. For overhead switches, Toronto Hydro is managing and renewing them through broader renewal efforts on the entire overhead system (e.g. area rebuilds) or through reactive programs. On their own, overhead switches do not drive or merit a “dedicated” approach at this time.

d) See response to part (c). Similar to overhead switches, conductors do not drive or merit a “dedicated” approach at this time.

e) Toronto Hydro utilizes tools such as asset condition assessment (“ACA”), predictive failure modelling, historical reliability analysis, and economic risk-based analysis results when determining how to direct capital expenditures at all stages of the Asset Management (“AM”) Process illustrated in Figure 2 of Exhibit 2B, Section D1. The specific interaction varies depending on the component of the AM Process being engaged and the specific type of capital (program or project) being considered.

For example, during the Investment Planning and Portfolio Reporting (“IPPR”) process, a planner responsible for Stations Renewal will utilize all of the aforementioned tools but may choose to place incremental weight on predictive failure modelling, while a planner responsible for Overhead System Renewal may choose to place incremental weight on historical reliability analysis or economic risk-based analysis when developing portfolio and program capital expenditure proposals. (Contributions to reliability measures are greater from the overhead system than they are from stations.) During the IPPR process, senior management will similarly utilize the same tools to assess the expenditure levels proposed for each program and the overall mix of capital proposed across all programs.
Another example occurs at the Scope and Project Development component of the AM Process. To identify specific needs, assess options, and ultimately develop scopes of work, planners will utilize ACA and economic risk-based analysis to prioritize individual assets for intervention (e.g. replacement), and identify clusters of poor condition or high risk assets that can be grouped into a project within a given program. Other tools such as historical reliability analysis and predictive failure modelling may be used to provide results at a feeder or group level. In these situations, Toronto Hydro uses the tools to make specific decisions about where capital should be directed within particular parts of the distribution system.

A third example comes from the Program Management & Execution component of the AM Process. At this stage, Toronto Hydro utilizes the referenced tools to prioritize projects for execution and to create the following year’s work program. Projects addressing greater numbers of assets in HI4 or HI5 (asset condition assessment) categories or feeders with particularly poor historical reliability may be prioritized over other projects. For more information about project prioritization, please see Toronto Hydro’s response to interrogatory 2B-SEC-36 (a). At this stage, the tools are utilized to direct capital expenditures within a specific year or defer available projects (and their associated capital) to later years.

Please note that although this response has focused on the four tools referenced in the question, Toronto Hydro applies a wide variety of tools and indicators throughout the AM Process to make effective capital decisions. An example of this may be found in Exhibit 2B, Section E6.6, at page 57, in relation to the Stations Renewal program. The tools and indicators listed (and considered) when planning that program are reproduced below for ease of reference:
1) Age
2) Dissolved gas-in-oil analysis
3) Condition Assessment
4) Loading
5) Load
6) PCB concentration in oil
7) Resiliency of the surrounding distribution system to withstand transformer failures
8) Any other electrical tests (such as power factor and insulation resistance tests)
9) Voltage conversion planned

f) A scope of work document is produced for every project. A sample scope of work document is provided in Appendix A.
Project Documentation

Date Posted: 27-Apr-16  Date Revised: 22-Aug-17

Project Title: X18256 Danforth 4kV Conversion Phase 1 - B4DA, B1DA TOB1DA

Prioritization Score: 100  Estimate #: 38914

AM Estimated Cost: $2,468,821  Construction by: Q1-Q4  2018

Objective:
To convert 4.16kV feeders B4DA and B1DA to 13.8kV standards with new feeders A260DA and A274DA, respectively. Ties between A200E and A260DA as well as between A260DA and A274DA will be created for contingency scenarios.

This project is the first phase of a multi-phase plan to convert all 4kV load to 13.8kV with the eventual goal of decommissioning the B1-2DA 4kV bus.

Category: System Renewal  Activity Code: 154

Program: Box Construction Conversion

Sub Program:

Project Boundaries (Where Applicable)  Multiple Locations: Yes

East: West Lynn Ave  West: Coxwell Ave
North: Danforth Ave  South: GO Train Tracks

Related Projects:
The Following Projects Must Be Completed Prior To This Project
X16328 MAIN TS A1-2MN Bus Repl. PHASE 2 (Civil), S18279 Danforth TS Prepare Cells #3 & 8 "Dis Sup"

The Following Projects Must Be Completed Following This Project:

Planner: Nikola Dimiskovski  Engineer: Matthew Yee
Business Units/ External Utility
☑ Distribution Services Eas
☐ Distribution Services Wes
☐ CCM East
☐ CCM West
☐ Stations Distribution Automation
☐ Building Facilities
☐ Coordinate with City/ Bell/ Roger/TTC/HO
☐ Easement Require
☐ Cost Sharing/Recoverable %

SCOPE

Background:

Box construction feeders, such as B4DA and B1DA, are a functionally obsolete legacy construction standard with numerous safety concerns and capacity limitations.

Assumptions:

Assume 4kV poles will be replaced at the same location by 13.8kV poles.
Description of Work:

SEE ATTACHED MAPS FOR MORE DETAIL

NOTES:
- This scope will follow the civil reinforcement work around Danforth Station with scope X16328
- The B6DA feeder will continue to operate as the standby for the 4kV areas until they are converted

1. CONNECT A260DA AND A274DA FROM THE A1-2DA 13.8kV BUS AT DANFORTH STATION

- Connect new feeders A260DA to cell no. 3 and A274DA to cell no. 8 on the A1-2DA bus. These cells should be prepped with scope S18279.
- Extend A260DA and A274DA to conversion areas using 500 kcmil triplexed TRXPLE cable and 1 neutral cable using the routes defined below. The S18279 scope will ensure that there is a neutral at the A1-2DA bus.
- Conduct civil inspections and rebuild cable chambers and ducts if necessary.

2. EXTEND A260DA AND NEUTRAL (1460m of cable)

- Use the following cable chamber route for A260DA and neutral: 8000, 8002, 8003, 8025, 8012, 8013, 8014, 7347, 8015, 8016, 5846, 8017, 5845, 5973, 5375, 5375, 5374, 5977, 5373, 5979, 5372, 5991, 5371, 5994, 5370, 5998, 5369, 6040.
NOTE: Going immediately north to CC8011 from CC8002 is not recommended since CC8011 would require a rebuild which cannot be done due to a moratorium on Danforth Ave.
- Rise up on or near pole P167 on Hillingdon Ave and convert B4DA as described in step 4.

3. EXTEND A274DA (1100m of cable)

- Use the following cable chamber route for A274DA: 8000, 8002, 8003, 8025, 8012, 8013, 8014, 7347, 8015, 8016, 5846, 8017, 5845, 5973, 5375, 5375, 5374, 5977, 5373, 5979, 5372, 5991, 5371, 5994, 5995.
NOTE: Going immediately north to CC8011 from CC8002 is not recommended since CC8011 would require a rebuild which cannot be done due to a moratorium on Danforth Ave.
- Rise up on or near pole P169 on Bastedo Ave and convert B1DA as described in step 6.

4. CONVERT B4DA 4KV OVERHEAD WITH A260DA

A) OH CONDUCTOR: Approximate length to convert is 1379m (primary) and 2500m (secondary). Remove all 4.16kV OH conductors. Replace main trunk with 13.8kV 336 kcmil OH treeproof. Replace laterals with 13.8kV 3/0 OH treeproof. Replace all secondary conductors with 266 kcmil XLPE.

B) POLES: Replace 54 poles with 45ft cedar poles using appropriate anchoring.
C) OH SWITCHES: Replace lateral fuses and load break switches with 13.8kV standards.

D) TRANSFORMERS: Replace 4.16kV units with 13.8kV standard transformers. The number of transformers to be used as replacements will depend on the voltage drop limitations. Designer to conduct voltage drop calculations.

Replace the following with like-for-like 13.8kV OH transformers in accordance with voltage drop limitations:
- One 50kVA (2-phase, 600V Delta) OH transformer
- Two 100kVA (1-phase, 120/240V) OH transformers
- Two 167kVA (1-phase, 120/240V) OH transformers

The following OH transformers will need to be upgraded when replaced to 13.8kV standards because they are overloaded or highly loaded. Voltage drop calculations will dictate the number, size and configuration of the replacements:
- OT20639 (1-phase, 120/240V), size: 50 kVA, peak load: 39 kVA
- OT92636 (1-phase, 120/240V), size: 100 kVA, peak load: 82 kVA
- OT64174 (1-phase, 120/240V), size: 100 kVA, peak load: 275 kVA
- OT61967 (1-phase, 120/240V), size: 50 kVA, peak load: 96 kVA
- OT40887 (1-phase, 120/240V), size: 100 kVA, peak load: 102 kVA

Replace the following with like-for-like 13.8kV padmount transformers:
- One 112kVA (3-phase, 120/208V) padmount transformer
- One 225kVA (3-phase, 120/208V) padmount transformer
- One 300kVA (3-phase, 600/347V) padmount transformer

Replace the following padmount transformer will need to be upgraded when replaced to 13.8kV standards:
- Replace padmount transformer 5927 (3-phase, 120/208V, size: 150kVA) with a 300kVA 13.8kV replacement

5. CREATE FEEDER TIE BETWEEN A260DA AND A200E

- Create feeder tie between newly converted A260DA area and A200E (Carlaw feeder) at Hanson St and Coxwell Ave using a SCADA switch. Ensure to connect to main trunk (336kcmil) of A200E. This tie will be used during contingency scenarios.

6. CONVERT B1DA 4KV OVERHEAD WITH A274DA

A) OH CONDUCTOR: Approximate length to convert is 1283m (primary) and 2500m (secondary). Remove all 4.16kV OH conductors. Replace main trunk with 13.8kV 336 kcmil OH treeproof. Replace laterals with 13.8kV 3/0 OH treeproof. Replace all secondary conductors with 266 kcmil XLPE.

B) POLES: Replace 52 poles with 45ft cedar poles using appropriate anchoring.

C) OH SWITCHES: Replace lateral fuses and load break switches with 13.8kV standards.
D) TRANSFORMERS: Replace 4.16kV units with 13.8kV standard transformers. The number of transformers to be used as replacements will depend on the voltage drop limitations. Designer to conduct voltage drop calculations.

Replace the following with like-for-like 13.8kV OH transformers in accordance with voltage drop limitations:
- Three 100kVA (1-phase, 120/240V) OH transformers
- One 501kVA (3-phase, 600V Delta) OH transformer bank

The following OH transformers will need to be upgraded when replaced to 13.8kV standards because they are overloaded or highly loaded. Voltage drop calculations will dictate the number, size and configuration of the replacements:
- OT94193 (1-phase, 120/240V), size: 100 kVA, peak load: 92 kVA
- OT98849 (1-phase, 120/240V), size: 50 kVA, peak load: 75 kVA
- OT22206 (1-phase, 120/240V), size: 50 kVA, peak load: 125 kVA
- OT58961 (1-phase, 120/240V), size: 100 kVA, peak load: 80 kVA
- OT94081 (1-phase, 120/240V), size: 50 kVA, peak load: 54 kVA
- OT4422 (1-phase, 120/240V), size: 50 kVA, peak load: 66 kVA
- OT18360 (1-phase, 120/240V), size: 50 kVA, peak load: 125 kVA
- OT81266 (1-phase, 120/240V), size: 50 kVA, peak load: 90 kVA
- OT90333 (1-phase, 120/240V), size: 50 kVA, peak load: 58 kVA

7. CREATE FEEDER TIE BETWEEN A274DA AND A260DA

- Create feeder tie between newly converted A260DA and A274DA at Hanson St and Hillingdon Ave using a SCADA switch. This tie will be used during contingency scenarios.

8. REMOVE ALL UG PORTIONS OF B4DA and B1DA

Additional Notes:

Note-1: Please apply latest Standard Design Practices (SDP).
Note-2: Please abide by ESA Requirements referring to Ontario Regulation 22/04 Section 11. This section relates to the disconnection of unused lines.
Note-3: Designers are to ensure that all leaking PILC cables (leakers) and Raychem lead repair kits that may exist within the limits of this project be identified, documented and repaired/replaced in conjunction with this project.
Note -4: Designers to include all necessary equipment nomenclature and cable tagging in the design for field implementation. [This is applicable mainly for downtown Toronto]
Note-5: For horseshoe area, if the replacement of the feeder cables for a vault is in the scope, upgrade vault to current standards by replacing all existing devices, cables and any other component that may prove unreliable due to age and/or conditions.
Note-6: Related to UG TX replacement, instructions for contractors must include specifications that vaults be cleaned and drains proven before installing the equipment.
Note- 7: All grounding deficiencies within the proposed project area be identified in the design and corrected during construction
Note-8: During the replacement of a pole mount transformer having a Transformer Monitor already installed on it, designer is to leave proper instruction for the construction crew that the existing Transformer Monitor is re-installed with the newly replaced transformer. Similarly
during the replacement of a pole and the connected conductor, designer is to instruct construction group to reinstall the monitoring devices (Power Line Monitors are clamped to the conductors and the Data Collectors are mounted approximately half way up on the pole) back to the replaced pole and conductor.

Note-9: Designer to check City Program and Moratorium.
Note-10: Foreign Attachment (check with Kate Parkinson).
Note-11: Design hours= , Site visit hours = .
# TPUCC

## Project Boundary

<table>
<thead>
<tr>
<th>Street #</th>
<th>Major Street Name</th>
<th>Street Type</th>
<th>From</th>
<th>Street Type</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DANFORTH</td>
<td>Avenue</td>
<td>COXWELL</td>
<td>Avenue</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WEST LYN</td>
<td>Avenue</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>Project Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Timing

<table>
<thead>
<tr>
<th>Start Year</th>
<th>End Year</th>
<th>Construction Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Unit of Measure:

<table>
<thead>
<tr>
<th>OH</th>
<th>OH UG</th>
<th>UG - Civil</th>
<th>OH and UG</th>
<th>UG Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Poles</td>
<td># of Spans</td>
<td>SCADA Switches</td>
<td>Per meter of roadway</td>
<td># of Services</td>
</tr>
</tbody>
</table>

### TRANSFORMERS

<table>
<thead>
<tr>
<th>U/G Primary</th>
<th>Dry Transformer</th>
<th>Network Transformer</th>
<th>Padmount Transformer</th>
<th>Polemount Transformer</th>
<th>Submersible Transformer</th>
<th>Vault Transformer</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Resources Type (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Cable Person (TCBLP)</td>
</tr>
</tbody>
</table>

| Power Cable Person (TCBLP) | Certified Power Line Person (TJOIN) | Jointer (TJOIN) | Electrical Mechanic (TMECE) | Crew Leader (TLDRC) | F39Cable Installer (TINST) | Certified Crew Leader (TCRWL) | Dist and Design Technician (TTECD) | Civil Design (TDESG) |
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 68:

Reference(s): Exhibit 2B, Section D4, p. 1

a) Please provide a list of the asset categories that are included in the facilities asset management strategy (Exhibit 2B / Section D4 / p. 1).

RESPONSE:

As discussed in Exhibit 2B, Section E8.2, page 2 (line 6) to page 3 (line 4), the following facilities asset categories are included in the Facilities Asset Management Strategy:

1) Architectural;
2) Fire & Life Safety;
3) Mechanical & Electrical;
4) Civil; and
5) Plumbing.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 69:
Reference(s): Exhibit 2B, Section D, Appendix A, pp. 6-7

Preamble:
In the Distribution System Plan Asset Management Review, UMS Group states that it did not directly examine Toronto Hydro’s asset data and instead relied on interviews regarding the data.

UMS Group also states that Toronto Hydro does not use a standardized method tracking the risk of deferred investments and that asset class level risk registers would assist in ensuring risks beyond reliability are kept within certain tolerances (Exhibit 2B / Section D / Appendix A / pp. 6-7).

a) Please explain why UMS Group did not take a sampling of Toronto Hydro’s asset data to determine whether it is sufficient to support asset management decision-making processes (Exhibit 2B / Section D / Appendix A / p. 6). Please advise whether UMS Group typically would look at the asset data in completing a review of this nature.

b) Please provide Toronto Hydro’s response to the improvements recommended by UMS Group (i.e. standardized method for tracking the risk of deferred investments and risk registers) (Exhibit 2B / Section D / Appendix A / pp. 6-7).
RESPONSE (PREPARED BY UMS):

a) Rather than directly sample data, UMS Group’s typical approach to a review of this nature is to discuss the data used to support decision-making and ask questions intended to provide insight into the availability and quality of data. In addition, UMS Group seeks to understand the efforts that are being undertaken to improve data, where the cost incurred can be justified by the benefit provided by better data. Taken together, these lines of inquiry are generally sufficient to provide an understanding of how the data is being used to support the asset management decision-making processes and if data availability and quality is a significant hindrance to the asset management system.

RESPONSE (PREPARED BY TORONTO HYDRO):

b) While UMS Group believes that the lack of a highly standardized process is not a major detriment to the asset management system, a more standardized process in this area would provide incremental benefit by ensuring that future risk is uniformly understood and tracked over time. In response to this recommendation, Toronto Hydro has taken the recommendations provided by the UMS Group under advisement and intends to evaluate the costs and benefits of the proposed improvements as part of the utility’s continuous improvement efforts in Asset Management.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 70:

Reference(s): Exhibit 2B, Section D, Appendix A, pp. 7, 9-11

Preamble:
UMS Group scored Toronto Hydro at an average maturity level of 2.1 across the 11 ISO 55001 domains that were assessed. In total, there are 24 ISO 55001 domains. UMS Group states that it only evaluated Toronto Hydro on 11 of the domains as some are not directly involved in the development of a DSP and Toronto Hydro wanted a more focused evaluation.

UMS Group compared Toronto Hydro’s asset management maturity to 14 transmission and distribution utility business units for which UMS Group had previously conducted assessments (Exhibit 2B / Section D / Appendix A / p. 7).

a) Please provide the full list of 24 domains and explain why the subset of 11 were selected (Exhibit 2B / Section D / Appendix A / p. 7).

b) Please confirm that the reason Toronto Hydro was compared to the selected 14 transmission and distribution utility business units was due to UMS Group only completing these types of reviews for 14 other utilities (Exhibit 2B / Section D / Appendix A / p. 11).

c) Please explain the difference between the “DSP Review Domains” presented in Table III-1 (Exhibit 2B / Section D / Appendix A / p. 9) and the “DSP Domains” shown in column 1 of Table III-2 (Exhibit 2B / Section D / Appendix A / p. 10).
d) Please explain the following statement: “while these utilities were not specifically selected to represent the industry as a whole... UMS Group believes that the results are consistent with its qualitative view of asset management maturity across the North American utility industry” (Exhibit 2B / Section D / Appendix A / p. 11). Please advise whether this means that the comparator group is representative of the North American industry.

e) In its summary of results, UMS Group provided a number of potential improvements (e.g. risk of deferred investments is not assessed beyond reliability). Please provide Toronto Hydro’s plan to respond to these recommendations (Exhibit 2B / Section D / Appendix A / pp. 12-16).

f) Please further explain why the level of condition assessment used to drive investments varies for different asset classes (Exhibit 2B / Section D / Appendix A / p. 14).

RESPONSE (PREPARED BY UMS):

a) In order to determine the ISO 55001 domains to assess, UMS Group first defined a set of domains which reflected its view of the key asset management competencies needed to develop and execute of the DSP. Please refer to Table III-1: DSP Review Domains (Exhibit 2B / Section D / Appendix A / p. 9) for a list of the DSP Review Domains. These DSP domains were then linked to relevant ISO 55001 domains resulting in the 11 ISO 55001 domains which were chosen. Please refer to Table III-2: Relationship between ISO 55001, SAM Model, and DSP Domains (Exhibit 2B / Section
D / Appendix A / p. 10). A complete list of the 24 domains of the ISO 55001 standard is shown in Table 1 below.

Table 1: List of ISO 55001 Domains

<table>
<thead>
<tr>
<th>Domain</th>
<th>Description</th>
<th>Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Understanding the organization and its context</td>
<td>6.2 Asset management objectives and planning to achieve them</td>
<td>8.2 Management of change</td>
</tr>
<tr>
<td>4.2 Understanding the needs and expectations of stakeholders</td>
<td>7.1 Resources</td>
<td>8.3 Outsourcing</td>
</tr>
<tr>
<td>4.3 Determining the scope of the asset management system</td>
<td>7.2 Competence</td>
<td>9.1 Monitoring, measurement, analysis and evaluation</td>
</tr>
<tr>
<td>4.4 Asset management system</td>
<td>7.3 Awareness</td>
<td>9.2 Internal audit</td>
</tr>
<tr>
<td>5.1 Leadership and commitment</td>
<td>7.4 Communication</td>
<td>9.3 Management review</td>
</tr>
<tr>
<td>5.2 Asset management policy</td>
<td>7.5 Information requirements</td>
<td>10.1 Nonconformity and corrective action</td>
</tr>
<tr>
<td>5.3 Organizational roles, responsibilities and authorities</td>
<td>7.6 Documented information</td>
<td>10.2 Preventive action</td>
</tr>
<tr>
<td>6.1 Actions to address risks and opportunities for the asset</td>
<td>8.1 Operational planning and control</td>
<td>10.3 Continual improvement</td>
</tr>
<tr>
<td>management system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) The 14 transmission and distribution utility business units used for comparison are those for which UMS Group has performed recent engagements which included an asset management maturity assessment. The actual scope of the engagements may not have been the same as the DSP review performed for Toronto Hydro, but they all included an AM maturity assessment using the same requirements as the ISO 55001 standard to which Toronto Hydro was compared.

c) There is no difference. The “DSP Review Domains” presented in Table III-1 (Exhibit 2B / Section D / Appendix A / p. 9) and the “DSP Domains” shown in column 1 of Table III-2 (Exhibit 2B / Section D / Appendix A / p. 10) are identical. Table III-2 merely links the
DSP Review Domains from Table III-1 to the corresponding Strategic Asset Management Model Domains and the ISO 55001 Domains.

d) Please refer to UMS Group response to 2B-SEC-43 (e).

RESPONSE (PREPARED BY TORONTO HYDRO):
e) Toronto Hydro has taken the recommendations provided by the UMS Group under advisement and intends to evaluate the costs and benefits of the proposed improvements as part of the utility’s continuous improvement efforts in Asset Management.

RESPONSE (PREPARED BY UMS):
f) It is typical within the utility industry for the level of condition assessment used to drive investments to vary for different asset classes. First, different asset classes have different factors that indicate when they are near their useful end-of-life and require an investment intervention. Some factors are condition-based (e.g., corrosion, rot, etc.) while others are not (e.g., functional obsolescence, regulatory requirements, etc.). Second, even for asset classes where condition assessment drives end-of-life, the cost of acquiring information on the condition of the assets may not be commensurate with the benefit obtained by knowing more about the condition. Finally, the consequence of failure differs for asset classes, some have a minimal impact if they fail, so are designated run-to-failure. For these assets, no different decision would be made even if condition were known, so investment decisions are driven by factors other than condition.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 71:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 9, 11-13

If available, please provide the future health scores in the same format as Table 3 (Exhibit 2B / Section D / Appendix C / p. 11) under the assumption that the DSP (and associated spending) is approved as filed.

Please provide a list of major asset classes for which health score information is not currently available (Exhibit 2B / Section D / Appendix C / p. 12). Please advise whether Toronto Hydro is working towards gathering the necessary information in order to calculate the health score information for these major asset classes in the future.

Please advise whether Toronto Hydro plans to add new measures, similar to the System Health – Asset Condition (Poles), to its performance measures in the future (Exhibit 2B / Section D / Appendix C / p. 12).

Toronto Hydro notes that it intends to update its useful life values and age-based probability of failure curves in the future (Exhibit 2B / Section D / Appendix C / p. 13). Please advise whether Toronto Hydro is intending to file this information in its next rebasing proceeding.

RESPONSE:

a) This information is not available at this time. Conceptually, there are two ways to generate future health score profiles taking into account planned investment levels.
The first is to identify the specific assets the utility plans to replace over the entire investment period. This approach is not feasible over a five-year planning horizon. The second approach is to develop a model that uses allocative assumptions and projected failure rates to apportion different amounts of planned spending across the five asset health bands. Toronto Hydro intends to explore this type of modelling as it gains experience with its new Asset Condition Assessment methodology.

b) 

- **Underground Cables**: As mentioned in Exhibit 2B, Section D, Appendix C, on page 11-12, Toronto Hydro does not have an ACA methodology for underground cables, but is currently implementing a new cable testing approach that could potentially support the development of an ACA.

- **Pole Top Transformers**: Toronto Hydro does not have an ACA methodology for pole top transformers. The utility is exploring leveraging loading information and location information to develop an ACA using the new methodology.

- **Station Switchgear**: Toronto Hydro does not have enough data to establish a health score algorithm for this asset. The utility’s recent Reliability Centered Maintenance (RCM) analysis identified additional data that Toronto Hydro could consider collecting on its switchgear assets to support the creation of a condition algorithm. Toronto Hydro intends to evaluate the costs and benefits of collecting this additional information.

- Toronto Hydro has not developed a health score algorithm for **Automatic Transfer Switches** and **Reverse Power Breakers** as these are obsolete assets that the utility is in the process of phasing out.
c) Toronto Hydro will consider the merits of different asset condition related measures as it gains experience managing the System Health – Asset Condition (Poles) measure and using the new Asset Condition Assessment methodology over the 2020-2024 period.

d) If Toronto Hydro completes these updates prior to its next rebasing application, then it will file them as part of the record in that proceeding.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 72:

Reference(s): Exhibit 2B, Section D, Appendix D

Preamble:
Toronto Hydro has undertaken an in-depth study titled, Climate Change Vulnerability Assessment. The study looked at the vulnerability of Toronto Hydro’s system to a changing climate.

a) Please explain how the capital programs contained in the distribution system plan address the results found in the noted study.

RESPONSE:

a) The explanation is provided in the evidence at Exhibit 2B, Section D2.1.2.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 73:

Reference(s): Exhibit 2B, Section E2, pp. 6-8, 12
Exhibit 2B, Section A1, p. 1
Chapter 2 Appendices, Appendix 2-AA

Preamble:
Toronto Hydro notes that through its iterative planning activities it developed an initial, penultimate and final capital plan.

a) Please provide a summary table that compares the capital expenditures included in each of the iterations of the capital plan. Please provide the summary table at the same level of detail as Appendix 2-AA (if possible). Please provide rationale supporting all major adjustments between each iteration of the plan.

b) With respect to changes between the penultimate and final plan, Toronto Hydro noted that it made adjustments to reflect customer support for programs related to preventing network floods and fires (Exhibit 2B / Section E2 / p. 7). Please list all programs in the DSP that address network flood and fire issues. Please provide the dollar amount of the changes made between the penultimate and final plan to address these issues.

c) With respect to the system renewal category, Toronto Hydro reduced the budget by $325 million between the initial and penultimate versions of the plan. Between the penultimate and final plans, Toronto Hydro increased system renewal expenditures by $70 million (Exhibit 2B / Section E2 / pp. 6-7). Please explain how
Toronto Hydro expects current levels of system average reliability to be maintained with this overall decrease to expenditures (as between the initial and final plans).

With respect to the system service capital programs, the capital expenditures were reduced by $110 million between the initial and final plans. The reductions include changes to the scope of work and pacing of system enhancement programs (e.g. SCADA-switch installation in the Horseshoe Region of Toronto) (Exhibit 2B / Section E2 / pp. 6-8). Toronto Hydro noted that “technology and innovation are driving a more dynamic system that is transitioning away from the usual patterns of supply and demand, adding additional complexity and urgency to the challenge of modernizing the grid…” (Exhibit 2B / Section A1 / p. 1). Please explain how this urgency can be accommodated when the projects associated with addressing these issues are being undertaken at a slower pace.

In 2015, Toronto Hydro’s percentage of assets past end of useful life was 26% (with an additional 7% forecasted to reach expected useful life by 2020). Toronto Hydro’s percentage of assets past end of useful life in 2018 is 24% (with an additional 9% expected to reach that point by 2025) (Exhibit 2B / Section E2 / p. 12). Please explain why there has been very little change in the assets past useful life metrics in the context of the significant capital investment made during the 2015-2019 period.
RESPONSE:

a) Table 1 below describes the changes between the initial and penultimate capital plans at the program level. Table 2 explains the changes between the penultimate and final capital plans.

Table 1: Financial Planning: Capital Program Optimization

<table>
<thead>
<tr>
<th>Program/Category</th>
<th>2020-2024 Total Capital Exp.</th>
<th>Initial Plan ($M)</th>
<th>Penultimate Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer and Generation Connections</td>
<td></td>
<td>212.9</td>
<td>176.0</td>
<td>Updated forecast</td>
</tr>
<tr>
<td>Externally Initiated Plant Relocations and Expansions</td>
<td></td>
<td>55.5</td>
<td>42.2</td>
<td>Updated forecast</td>
</tr>
<tr>
<td>Load Demand</td>
<td></td>
<td>63.9</td>
<td>63.9</td>
<td></td>
</tr>
<tr>
<td>Metering</td>
<td></td>
<td>154.2</td>
<td>125.8</td>
<td>Refined estimates for the wholesale metering, suite metering, and meter sampling activities. Deferred some planned meter replacements. Removed reactive meter replacements as these were appropriately captured in the Reactive and Corrective Capital program.</td>
</tr>
<tr>
<td>Generation Protection, Monitoring and Control*</td>
<td></td>
<td>12.9</td>
<td>12.9</td>
<td></td>
</tr>
<tr>
<td>System Access (Total)</td>
<td></td>
<td>499.5</td>
<td>420.9</td>
<td>Deferred conversion work in areas with very low concentrations of Rear Lot and Box Construction to beyond 2024, as Toronto Hydro considered this to be the lowest priority type of conversion work with the lowest forecast contribution to 2020-2024 reliability sustainment objectives.1</td>
</tr>
<tr>
<td>Area Conversions</td>
<td></td>
<td>266.8</td>
<td>176.3</td>
<td></td>
</tr>
</tbody>
</table>

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1 As explained in Exhibit 2B, Section E6.5, Toronto Hydro will continue to convert 4 kV overhead circuits with poor reliability performance and/or a high risk of failure as part of normal Overhead System Renewal project planning and prioritization. Due to the overall age, condition, inefficiency, and functional obsolescence of the remaining 4 kV plant, Toronto Hydro anticipates a necessary ramp-up in proactive conversion work after 2024.
<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Initial Plan ($M)</th>
<th>Penultimate Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground System Renewal – Horseshoe</td>
<td>511.1</td>
<td>360.8</td>
<td>Reduced the pacing of direct-buried cable replacement to strictly maintain, as opposed to improve, average reliability and cable failure risk during the 2020-2024 period.</td>
</tr>
<tr>
<td>Underground System Renewal – Downtown</td>
<td>80.8</td>
<td>75.9</td>
<td>Minor adjustments to forecast.</td>
</tr>
<tr>
<td>Network System Renewal</td>
<td>106.6</td>
<td>79.6</td>
<td>Reduced the pacing of network unit renewal to maintain, as opposed to improve, the risk of catastrophic failure, and reduced the pacing of network vault renewal to better align with program execution capabilities.</td>
</tr>
<tr>
<td>Overhead System Renewal</td>
<td>256.5</td>
<td>203.7</td>
<td>Reduced the pacing of overhead rebuilds in alignment with the objective of maintaining average reliability and pole condition over the plan period.</td>
</tr>
<tr>
<td>Stations Renewal</td>
<td>99.0</td>
<td>93.3</td>
<td>Minor adjustments to forecast.</td>
</tr>
<tr>
<td>Reactive and Corrective Capital</td>
<td>202.8</td>
<td>207.8</td>
<td>Minor adjustments to forecast.</td>
</tr>
<tr>
<td><strong>System Renewal (Total)</strong></td>
<td><strong>1,523.5</strong></td>
<td><strong>1,197.4</strong></td>
<td></td>
</tr>
<tr>
<td>System Enhancements</td>
<td>116.1</td>
<td>50.6</td>
<td>(1) Reduced the pacing of SCADA switch installations and other Contingency Enhancement activities to better align with low-volume customer preferences for maintaining current average reliability performance; (2) substantially reduced the scope of Downtown Contingency enhancement projects in light of anticipated execution challenges.</td>
</tr>
<tr>
<td>Energy Storage Systems*</td>
<td>70.0</td>
<td>50.0</td>
<td>Reduction in the number of planned Energy Storage projects, pending additional needs and opportunities assessments</td>
</tr>
<tr>
<td>Network Condition Monitoring and Control</td>
<td>35.4</td>
<td>35.4</td>
<td>Minimum desired pacing for the utility’s network system modernization strategy, with substantial target benefits in five of six outcome categories</td>
</tr>
<tr>
<td>Stations Expansion</td>
<td>105.6</td>
<td>170.6</td>
<td>Increased budget for HONI expansion contributions in anticipation of additional capacity needs driven by longer-term urban development plans in Toronto.</td>
</tr>
<tr>
<td><strong>System Service (Total)</strong></td>
<td><strong>327.1</strong></td>
<td><strong>306.6</strong></td>
<td></td>
</tr>
</tbody>
</table>
Overall, the result of the changes in Table 1 was an approximate $550 million2 per year capital expenditure plan for 2020-2024, deferring approximately $75 million per year in forecast average capital expenditures from the initial proposals for the period. This penultimate plan was subsequently refined and finalized as described in the following table.

Table 2: Distribution System Plan Development: Final Program Adjustments

<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Penultimate Plan ($M)</th>
<th>Final Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer and Generation Connections</td>
<td>176.0</td>
<td>151.9</td>
<td>Updated projections accounting for 2017 actuals.</td>
</tr>
<tr>
<td>Externally Initiated Plant Relocations and Expansions</td>
<td>42.2</td>
<td>42.3</td>
<td></td>
</tr>
</tbody>
</table>

2 This figure includes inflation and other allocations, and excludes Renewable Enabling Improvement ("REI") expenditures funded through provincial rate relief.
<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Penultimate Plan ($M)</th>
<th>Final Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Demand</td>
<td>63.9</td>
<td>69.9</td>
<td>Increased planned spending to address four additional highly loaded feeders during the 2020-2024 period, which allows Toronto Hydro to improve rather than maintain the current number of highly loaded feeders. This change was made to better support the utility’s objective of maintaining reliability while improving system capacity and resiliency and ensuring the efficient connection of customers in areas of concentrated growth; this will also support the execution of other planned work in highly loaded areas.</td>
</tr>
<tr>
<td>Metering</td>
<td>125.8</td>
<td>105.8</td>
<td>To accommodate program adjustments in other areas, including adjustments occasioned by customer feedback in the second phase of Customer Engagement, the utility compressed its metering renewal schedule into the future, increasing the execution risk of the program while remaining within management tolerances, and decreasing the planned expenditures in the 2020-2024 period.</td>
</tr>
<tr>
<td>Generation Protection, Monitoring and Control*</td>
<td>12.9</td>
<td>13.6</td>
<td>Revised distributed energy resource connections forecast identified the need for an additional bus-tie reactor to alleviate short-circuit constraints during the 2020-2024 period.</td>
</tr>
<tr>
<td>System Access (Total)</td>
<td>420.9</td>
<td>383.4</td>
<td>Transferred remaining expenditure amounts for non-Rear Lot and non-Box Construction 4 kV conversion projects (see “Area Conversions” in Table 1 above) to the Underground System Renewal – Horseshoe program to address higher-priority direct-buried cable projects, some of which involve legacy 4 kV underground assets.</td>
</tr>
<tr>
<td>Area Conversions</td>
<td>176.3</td>
<td>171.1</td>
<td>Transferred from Area Conversions (see above).</td>
</tr>
<tr>
<td>Underground System Renewal - Horseshoe</td>
<td>360.8</td>
<td>365.9</td>
<td></td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Penultimate Plan ($M)</th>
<th>Final Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground System Renewal - Downtown</td>
<td>76.0</td>
<td>97.5</td>
<td>Following the decision to defer the Downtown Contingency plan (see “System Enhancements” below), the utility reallocated funding to this program, primarily to address approximately 15 km of additional high-risk lead cable serving customers in the same area as those who would have benefited from Downtown Contingency enhancements; this will help Toronto Hydro meet its objectives of maintaining reliability over the period. As demonstrated in the results on page 16 of the Customer Engagement report, there was strong support for lead cable replacement, including plurality support in the lower volume customer classes for accelerating the rate of replacement (Exhibit 1B, Tab 3, Schedule 1, Appendix A).</td>
</tr>
<tr>
<td>Network System Renewal</td>
<td>79.6</td>
<td>74.4</td>
<td>(1) A revised assessment of remaining legacy “ATS” and “RPB” network equipment revealed the opportunity to finish addressing these assets earlier than planned, resulting in an $11M reduction to the Legacy Network Equipment segment in this program. (2) As noted in Exhibit 2B, Section E2.3.2.3, network unit replacement was one of the renewal programs that received the strongest support from customers; in response, the utility used expenditure reductions elsewhere to increase the pace of non-submersible network unit renewal by three per year, driving greater reductions in reliability and safety risk during the 2020-2024 period.</td>
</tr>
<tr>
<td>Overhead System Renewal</td>
<td>203.7</td>
<td>203.7</td>
<td></td>
</tr>
</tbody>
</table>
### 2020-2024 Total Capital Exp.

<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Penultimate Plan ($M)</th>
<th>Final Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations Renewal</td>
<td>93.3</td>
<td>116.5</td>
<td>The initial proposal for Stations Renewal pacing was based in part on the amount of stations work the utility has been able to accomplish historically. However, this proposal was sub-optimal in that it failed to keep pace with accumulating asset risk and increasing failure frequency for major stations assets. During the Distribution System Plan development process, Toronto Hydro re-examined its execution capacity for stations work going forward and determined that sufficient capacity had been developed since 2015 to support a more optimal pacing. As a result, the utility increased planned expenditures in this program to address a substantial backlog of critical aging and obsolete assets, primarily to allow the utility to maintain MS Switchgear assets past useful life at 43% (instead of running the assets to 63% past useful life) and replace all obsolete and failing stations communication assets by 2024.</td>
</tr>
<tr>
<td>Reactive and Corrective Capital</td>
<td>207.8</td>
<td>240.6</td>
<td>Updated projection accounting for 2017 actuals and underlying trends.</td>
</tr>
<tr>
<td><strong>System Renewal (Total)</strong></td>
<td><strong>1,197.4</strong></td>
<td><strong>1,269.7</strong></td>
<td>Deferred the Downtown Contingency plan (discussed in Exhibit 2, Section E4.2.3) entirely beyond 2024 to allow for a more detailed study of the available options for station-level ties in the downtown core.</td>
</tr>
<tr>
<td>System Enhancements</td>
<td>50.6</td>
<td>22.7</td>
<td>Following a more detailed assessment of needs and opportunities, the utility arrived at a modestly paced energy storage plan that includes $5M to support grid performance and $5M to support the growth of distributed renewable generation. Customer-specific energy storage projects are also included in the program and will be funded in accordance with the beneficiary pays principle.</td>
</tr>
<tr>
<td>Energy Storage Systems*</td>
<td>50.0</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
Panel: Distribution System Capital and Maintenance

<table>
<thead>
<tr>
<th>Program/Category</th>
<th>Penultimate Plan ($M)</th>
<th>Final Plan ($M)</th>
<th>Reason for Change / No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Condition Monitoring and Control</td>
<td>35.4</td>
<td>50.4</td>
<td>As explained in Exhibit 2B, Section E2.3.2.3, customers were largely supportive of spending more on monitoring and control technology to improve the utility’s ability to monitor for fires, floods and other risks on the network system. In response to this, Toronto Hydro leveraged reductions in other areas to boost planned investment in this program, and is now aiming to install monitoring equipment and fibre optic cable in approximately 90% of all network vaults by the end of 2024.</td>
</tr>
<tr>
<td>Stations Expansion</td>
<td>170.6</td>
<td>130.8</td>
<td>Final detailed review of capacity planning considerations led to a more conservative forecast of HONI expansion contributions.</td>
</tr>
<tr>
<td><strong>System Service (Total)</strong></td>
<td><strong>306.6</strong></td>
<td><strong>213.9</strong></td>
<td></td>
</tr>
<tr>
<td>Control Operations</td>
<td>34.8</td>
<td>40.1</td>
<td>Final refined project estimate.</td>
</tr>
<tr>
<td>Reinforcement Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities Management and Security</td>
<td>54.7</td>
<td>54.7</td>
<td></td>
</tr>
<tr>
<td>Fleet and Equipment</td>
<td>38.5</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>IT/OT Systems</td>
<td>231.4</td>
<td>246.4</td>
<td>Moderate increase in IT Software budget to address revised forecast of business requirements.</td>
</tr>
<tr>
<td>General Plant</td>
<td>359.4</td>
<td>379.7</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL CAPEX (2020-2024)</strong></td>
<td><strong>2,284.3</strong></td>
<td><strong>2,246.7</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Figures represent gross REI expenditures (i.e. including amounts funded through provincial rate relief)

1. In the result, Toronto Hydro produced an optimized and customer-aligned capital expenditure plan with an average investment of $562 million\(^3\) per year over the 2020-2024 period.

3. This figure includes inflation and other allocations, and excludes Renewable Enabling Improvement (“REI”) expenditures funded through provincial rate relief.
Toronto Hydro’s evidence in Exhibit 2B, Sections E2.1.2 and E2.1.3, notes that the utility reduced its System Access expenditures by approximately $65 million between the initial and penultimate plans and approximately $50 million between the penultimate and final plans. In generating this interrogatory response, Toronto Hydro discovered an error in the summation that resulted in these figures. As shown in the tables above, the correct figures for the System Access reductions are approximately $80 million between the initial and penultimate plans and approximately $40 million between the penultimate and final plans. Toronto Hydro can confirm that this error has no bearing on any other figures in the application.

b) Toronto Hydro’s Network System Renewal and Network Condition Monitoring and Control programs are designed to help reduce the significant risks associated with fires and flooding within network vaults. Details on how Toronto Hydro adjusted these programs in light of Customer Engagement results are provided in Table 2 in the response to part (a) of this interrogatory.

c) Tables 1 and 2 in response to part (a) of this interrogatory provide program-level descriptions of how and why Toronto Hydro adjusted System Renewal expenditure plan proposals between the initial and final plans. Overall, Toronto Hydro has optimized its planned System Renewal expenditures to maintain reliability and current levels of asset failure risk over the 2020-2024 period while having regard to customer feedback that limiting price increases was a paramount concern. To achieve this balance, Toronto Hydro has deferred investments that would further reduce certain elevated asset risks such as those associated with direct-buried cables. Reducing these risks sooner would support lower total asset lifecycle costs over the longer-term by mitigating higher reactive replacement costs and the avoidable costs associated with repeatedly visiting project areas to repair assets that could be rebuilt more
economically on a planned basis. For a detailed discussion of how Toronto Hydro
developed its System Renewal plan and the objectives of the plan, please refer to
Exhibit 2B, Section E2.

d) As explained throughout the application, technology advancements are driving a more
dynamic system that is transitioning away from usual patterns of supply and demand
toward more complex interactions and inputs in electricity generated and consumed.
The role of the utility continues to evolve to support new smart grid ecosystems,
comprising renewable and other distributed energy resources, microgrids, electric
vehicles, and growing interest in energy storage for power quality, off-peak storage,
and grid resilience. As such, Toronto Hydro’s planned investments in the 2020-2024
period will support the ongoing modernization of the grid in an integrated and cost-
effective manner. As explained throughout Section E2.2, these investments are not
isolated to the System Service program; they are integrated within planned
investments in all categories of investment. Some examples include:

- the introduction of technologies supporting SCADA enabled remote
  monitoring, sensing, protection, and control capabilities, in programs in all four
  investment categories: e.g., Metering (Section E5.4), Generation Protection,
  Monitoring and Control (Section E5.5), Stations Renewal (Section E6.6), and
  Network Conditioning Monitoring and Control (Section E7.3);
- supporting investments in various information technology software and
  communications technologies over the 2020-2024 period (Section 8.2);
- the Control Operations Reinforcement program (Section E8.1), which will
  support the continuity of grid modernization with respect to monitoring and
  controlling energy delivery and more complex and emerging energy
  management needs;
investments in the System Access and System Service portfolio that seek to
increase and enable distributed energy resource penetration in the grid such
as those described in the Customer Connections (Section E5.1) and the Energy
Storage Systems (Section E7.2) programs.

The proposed reduction in the overall System Service category is unrelated to these
drivers. As explained in Exhibit 2B, Section E4.2.3, reduced expenditures are largely
driven by lower forecasted capacity expansion needs in the Stations Expansion
program (E7.4) and a restrained pace of System Enhancement program (E7.1)
expenditures (to maintain current levels of reliability), as well as the completion of a
number of smaller System Service programs. These program reductions have been
partially offset by the introduction of the Network Condition Monitoring and Control
program, which aims to modernize the network system.

e) Toronto Hydro considers the 2% improvement in the assets past useful life metric to
be considerable progress and the sign of an effective capital investment program for
the reasons that follow.

1) Toronto Hydro estimates that the replacement value of the entire distribution
system is approximately $10 billion to $15 billion. To replace the 24% of assets
past useful life will require approximately $2.5 billion to $3.5 billion, and to
reduce this figure by 2% will require $200 million to $300 million (assuming
that all amounts go entirely to assets past useful life).

2) Toronto Hydro estimates that between 2015 and 2017, 4% of assets entered
into the “past useful life” range. To negate this negative contribution to assets
past useful life, Toronto Hydro estimates that $400 million to $600 million will
need to be invested (assuming all amounts go entirely to assets past useful
life).
3) In light of (i) and (ii), Toronto Hydro has managed to offset 6% (net) of assets past useful life (i.e. 2% reduction + 4% entering), which required an estimated $600 million to $900 million investment (assuming all amounts go entirely to assets past useful life). This has been done predominantly through System Renewal investments, which totaled $826 million over the 2015-2017 period (please see Exhibit 2B, Section 4.1, Table 1, page 2), with some contribution from System Access and System Service investments.

4) The deployment of capital in System Renewal can never be directed entirely (or even substantially in a number of cases) to assets past useful life for a variety of reasons. Two examples are that asset failures (as addressed through the Reactive & Corrective Capital program, Exhibit 2B, E6.7) often occur on assets that are not past useful life, and managing safety risks (e.g. Area Conversions, Exhibit 2B, E6.1) necessitates that capital be directed to assets that are not all past useful life.

The reasons identified above demonstrate why Toronto Hydro’s 2% improvement is considerable and furthermore are an indication of the magnitude of the challenge that assets past useful life pose. It is paramount that robust and adequately funded System Renewal programs be in place over the 2020-2024 period to ensure recent gains are not lost. This is especially true given the 9% of assets that are approaching useful life over the next 5 years (see Exhibit 2B, Section E2, page 12)
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 74:

Reference(s): Exhibit 2B, Section E3, pp. 5-6, 9

Preamble:
Toronto Hydro notes that based on historical trends and the end of the Independent Electricity System Operator’s (IESO) Feed-in Tariff (FIT) program in 2018, Toronto Hydro anticipates the pace of REG connections to slow slightly beginning in 2019. However, forecasted REG installations will be larger compared to the past due to cost reductions for solar panels. Between 2019 and 2024, Toronto Hydro forecasts approximately 830 incremental REG connections (totalling 69 MW) to the distribution system (Exhibit 2B / Section E3 / pp. 5-6).

a) Please provide more detailed evidence supporting Toronto Hydro’s REG connection and capacity forecasts for the 2019-2024 period (Exhibit 2B / Section E3 / pp. 5-6).

b) Please provide further evidence supporting Toronto Hydro’s claim that the REG installations will be larger capacity than historically (Exhibit 2B / Section E3 / p. 5).

c) Please provide a comparison of historical REG unit capacity size and forecasted REG unit capacity size (Exhibit 2B / Section E3 / p. 5).

d) Please advise whether the forecasted 581 MW of DG is the total forecast for the 2020-2024 period. Alternatively, advise whether this includes forecasts for 2018-2019 (Exhibit 2B / Section E3 / p. 9).
RESPONSE:

a) Toronto Hydro’s REG forecast is outlined in Exhibit 2B, Section E3, p. 3 and Exhibit 2B, Section E5.1, p. 17 and relies on:

- The Ontario’s Long Term Energy Plan (“LTEP”);
- The Ontario Ministry of Energy’s Market Analysis of Ontario’s Renewable Energy Sector (June 30, 2017); and
- Toronto Hydro’s historical REG connection trends.

Based on the above references, Toronto Hydro anticipates that REG connections will continue in Ontario, however, at a slower pace than experienced over the 2010-2017 period. In its forecast, Toronto Hydro assumed that starting in 2019, REG connections will amount to roughly two-thirds of the previous seven-year average and will increase yearly, at a conservative pace.

b) The International Technology Roadmap for Photovoltaics\(^1\) and Solar Cell Efficiency Tables (Version 52)\(^2\) demonstrate that the efficiency and module power of photovoltaic panels has increased when the same surface area is assumed. This trend is expected to continue. As such, customers will be able to increase project sizes using the existing rooftop space.

Table 1 below shows Toronto Hydro’s observations of increasing unit capacity size from solar photovoltaic installations within its service area. When estimating the REG unit capacity size for the 2019-2024 REG forecast, Toronto Hydro used a conservative


approach.

c) Please see Table 1.

d) The forecasted 581 MW of DG is the total forecast for the 2018-2024 period, whereby 2018-2019 represents 188 MW and 2020-2024 represents 393 MW.

Table 1: Breakdown of historical and forecasted REG unit capacity size (in kilowatts)

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<tr>
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</thead>
<tbody>
<tr>
<td><strong>Micro REG</strong></td>
<td>3.7</td>
<td>5.5</td>
<td>6.1</td>
<td>6.8</td>
<td>7.4</td>
<td>8.6</td>
<td>8.1</td>
<td>8.1</td>
<td>8.6</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Small REG</strong></td>
<td>147.5</td>
<td>150.3</td>
<td>184.6</td>
<td>184.7</td>
<td>166.4</td>
<td>223.9</td>
<td>207.0</td>
<td>221.9</td>
<td>230.9</td>
<td><strong>200.0</strong></td>
</tr>
</tbody>
</table>
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 75:

Reference(s): Exhibit 2B, Section E4, pp. 2-15
Chapter 2 Appendices, Appendix 2-AA
EB-2014-0116, Decision and Order, pp. 21, 27

Preamble:
Toronto Hydro provided the following summary table with respect to historical capital expenditure variance analysis. The comparison is based on planned vs. actual (as opposed to approved vs. actual) (Exhibit 2B / Section E4 / p. 2).

In its Decision and Order in Toronto Hydro’s 2015-2019 rates proceeding, the OEB ordered a 10% reduction to Toronto Hydro’s proposed capital expenditures and the application of the stretch factor to the C-factor (EB-2014-0116 / Decision and Order / pp. 21, 27).

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</tr>
</thead>
<tbody>
<tr>
<td>System Access</td>
<td>86.1</td>
<td>58.3</td>
<td>(32%)</td>
<td>95.3</td>
<td>79.0</td>
<td>(17%)</td>
<td>104.9</td>
<td>65.5</td>
<td>(38%)</td>
<td>95.8</td>
<td>100.8</td>
<td>5%</td>
</tr>
<tr>
<td>System Renewal</td>
<td>251.7</td>
<td>304.1</td>
<td>21%</td>
<td>239.6</td>
<td>266.1</td>
<td>11%</td>
<td>256.2</td>
<td>250.3</td>
<td>2%</td>
<td>275.9</td>
<td>229.4</td>
<td>17%</td>
</tr>
<tr>
<td>System Service</td>
<td>76.5</td>
<td>37.9</td>
<td>(50%)</td>
<td>70.7</td>
<td>53.3</td>
<td>(25%)</td>
<td>65.1</td>
<td>72.4</td>
<td>11%</td>
<td>52.6</td>
<td>41.4</td>
<td>21%</td>
</tr>
<tr>
<td>General Plant</td>
<td>104.6</td>
<td>79.4</td>
<td>(24%)</td>
<td>101.5</td>
<td>109.5</td>
<td>8%</td>
<td>30.3</td>
<td>98.9</td>
<td>226%</td>
<td>34.2</td>
<td>70.0</td>
<td>105%</td>
</tr>
<tr>
<td>Other</td>
<td>12.2</td>
<td>11.6</td>
<td>(5%)</td>
<td>11.6</td>
<td>3.7</td>
<td>(68%)</td>
<td>10.8</td>
<td>10.7</td>
<td>(1%)</td>
<td>11.5</td>
<td>6.3</td>
<td>(46%)</td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>531.1</td>
<td>491.4</td>
<td>(7%)</td>
<td>518.8</td>
<td>511.6</td>
<td>(1%)</td>
<td>467.4</td>
<td>497.8</td>
<td>7%</td>
<td>470.0</td>
<td>447.8</td>
<td>5%</td>
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System O&M

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<tbody>
<tr>
<td>128.8</td>
<td>116.1</td>
<td>(10%)</td>
<td>126.5</td>
<td>126.3</td>
<td></td>
<td>126.9</td>
<td>131.0</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
a) Please provide variance analysis similar to as shown in Table 1 (Exhibit 2B / Section E4 / p. 2) for each year 2015-2019 as follows:

i) Comparing OEB-approved capital expenditures and actual capital expenditures. Please show both variances in gross capital expenditures and net capital expenditures. At a minimum, please provide the comparison at the total capital expenditure level (i.e. not by capital category).

ii) Comparing OEB-approved capital in-service additions and actual capital in-service additions. Please show both variances in gross capital in-service additions and net capital in-service additions. At a minimum, please provide the comparison at the total capital in-service addition level (i.e. not by capital category)

b) Please provide variance analysis, at the capital program level similar to Appendix 2-AA, for the years 2015-2019 as follows:

i) Comparing planned capital expenditures and actual capital expenditures (with a breakdown of gross capital expenditures, associated capital or customer contributions and net capital expenditures).

ii) Comparing planned capital in-service additions and actual capital in-service additions (with a breakdown of gross capital in-service additions, associated capital or customer contributions and net capital in-service additions).

c) In table format, for all major capital projects (> $10 million) planned for the 2015-2019 period, please provide:

i) the planned capital expenditure amount.

ii) the actual capital expenditure amount (or latest forecast capital expenditure amount if not yet completed).

iii) the planned capital in-service addition amount by year.
iv) the actual capital in-service addition by year (or latest forecast if not yet completed).

d) With respect to part (c), for any major capital project that experienced a major cost variance or in-service date change, please provide additional supporting discussion.

RESPONSE:

a) As explained in Exhibit 2B, Section E4.1, the OEB’s envelope approval of capital related revenue requirement for the 2015-2019 CIR period did not include prescribed adjustments to the expenditure plans for specific programs or investment categories. The annual “2015 CIR (-10%)” expenditures in Appendix A were simply derived by applying a general 10% reduction to the annual capital expenditures filed in the 2015 to 2019 CIR application (EB-2014-0116). Toronto Hydro is unable to provide the requested information at an investment category level.

i) Please see Appendix A to this response.

ii) Please see Appendix B to this response.

b)

i) Please see Appendix C to this response.

ii) The in-service additions by program for 2015-2017 historical years are provided in Appendix D to this response. Toronto Hydro forecasts in-service additions on an asset basis, not by capital program for the 2018-2019 bridge years and is unable to
create the information requested in the time provided for interrogatory responses.

The methodology followed for in-service additions forecasts is described in Toronto Hydro’s response to interrogatory 2A-SEC-31.

c) Please see Appendix E to this response.

d) Please see Appendix E to this response.
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<td>460.2</td>
<td>419.4</td>
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<td>438.6</td>
<td>424.9</td>
<td>471.0</td>
<td>408.0</td>
<td>505.0</td>
<td>566.7</td>
<td>571.0</td>
<td>548.0</td>
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<td>548.0</td>
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Note: Variances due to rounding may exist.
### 2B-Staff-75: Appendix B

#### Historical

<table>
<thead>
<tr>
<th>In-Service Additions</th>
<th>2015</th>
<th>Actual</th>
<th>Var.</th>
<th>CIR Filing (-10%)</th>
<th>2016</th>
<th>Actual</th>
<th>Var.</th>
<th>CIR Filing (-10%)</th>
<th>2017</th>
<th>Actual</th>
<th>Var.</th>
<th>CIR Filing (-10%)</th>
<th>2018</th>
<th>Actual</th>
<th>Var.</th>
<th>CIR Filing (-10%)</th>
<th>2019</th>
<th>Actual</th>
<th>Var.</th>
<th>CIR Filing (-10%)</th>
</tr>
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<tr>
<td>Gross</td>
<td>526.8</td>
<td>465.4</td>
<td>-12%</td>
<td>635.6</td>
<td>617.1</td>
<td>-3%</td>
<td>474.4</td>
<td>549.0</td>
<td>14%</td>
<td>413.2</td>
<td>673.4</td>
<td>39%</td>
<td>493.2</td>
<td>470.6</td>
<td>-5%</td>
<td>2,543.1</td>
<td>2,775.5</td>
<td>9%</td>
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<td></td>
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<tr>
<td>Customer Contributions</td>
<td>(14.3)</td>
<td>(30.1)</td>
<td>110%</td>
<td>(14.4)</td>
<td>(32.8)</td>
<td>56%</td>
<td>(14.9)</td>
<td>(28.7)</td>
<td>48%</td>
<td>(15.5)</td>
<td>(64.5)</td>
<td>76%</td>
<td>(16.0)</td>
<td>(72.7)</td>
<td>355%</td>
<td>(75.1)</td>
<td>(228.9)</td>
<td>205%</td>
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<tr>
<td>Net</td>
<td>512.5</td>
<td>435.3</td>
<td>-15%</td>
<td>621.1</td>
<td>584.3</td>
<td>-6%</td>
<td>459.5</td>
<td>520.3</td>
<td>12%</td>
<td>397.7</td>
<td>608.9</td>
<td>35%</td>
<td>477.2</td>
<td>397.8</td>
<td>-17%</td>
<td>2,468.0</td>
<td>2,546.6</td>
<td>214%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Bridge

|                   | 2015    | Actual | Var. | CIR Filing (-10%) | 2016    | Actual | Var. | CIR Filing (-10%) | 2017    | Actual | Var. | CIR Filing (-10%) | 2018    | Actual | Var. | CIR Filing (-10%) | 2019    | Actual | Var. | CIR Filing (-10%) |
|                   |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Gross             |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Customer Contributions |       |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Net               |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |

#### Historical/Bridge

|                   | 2015    | Actual/Fcst | Var. | 2015-2019 |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |
|                   |         |             |      |           |         |        |      |                 |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Gross             |         |             |      |           | 2,543.1 | 2,775.5 | 9%   |               |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Customer Contributions |       |             |      |           | (75.1)  | (228.9) | 205% |               |         |        |      |                 |         |        |      |                 |         |        |      |                 |
| Net               |         |             |      |           | 2,468.0 | 2,546.6 | 214% |               |         |        |      |                 |         |        |      |                 |         |        |      |                 |
Toronto Hydro-Electric System Limited
EB-2018-0165
Interrogatory Responses
2B-STAFF-75
Appendix C
FILED: January 21, 2018
Page 1 of 1

2B-Staff-75: Appendix C
Capital Programs Table
Programs ($M)

2015
CIR Filing
Plan

Customer Connections Gross
Customer Connections Capital Contribution
Externally Initiated
Initiated Plant
Plant Relocations
Relocations &
& Expansion
Expansion Capital
Gross
Externally
Contribution
Generation Protection, Monitoring, and Control
Load Demand
Metering
System Access Total
Area Conversions
Network System Renewal
Reactive and Corrective Capital
Stations Renewal
Underground System Renewal - Downtown
Underground System Renewal - Horseshoe
Overhead Infrastructure Relocation
SCADAMATE R1 Renewal
PILC Piece Outs & Leakers
Underground Legacy Infrastructure
Overhead System Renewal
System Renewal Total
Energy Storage Systems Gross
Energy Storage Systems Capital Contribution
Network Condition Monitoring and Control
Overhead Momentary Reduction
Stations Expansion
System Enhancements
Handwell Upgrades
Polymer SMD-20 Renewal
Design Enhancement
System Service Total
Facilities Management and Security
Fleet and Equipment
IT/OT Systems
Control Operations Reinforcement
Operating Centers Consolidation Plan
Program Support
General Plant Total
AFUDC
Miscellaneous
Miscellaneous Capital Contribution
Other Total
Subtotal
Less Renewable Generation Facility Assets and Other Non
Rate-Regulated Utility Assets (input as negative)

53.9
(14.6)
6.6
(2.6)
6.1
12.0
24.7
86.1
33.8
9.6
33.1
16.8
96.0
0.7
6.2
3.5
2.1
44.0
245.7
0.5
44.0
21.7
5.0
4.8
0.4
76.5
16.5
3.9
51.8
37.4
1.2
110.7
8.0
4.2
12.2
531.1

Total

530.6

(0.5)

Actual
69.2
(37.4)
3.8
(1.6)
9.9
14.5
58.3
46.3
10.2
42.0
11.3
115.5
0.9
3.5
6.0
7.4
61.0
304.1
0.0
23.0
7.1
4.7
3.0
0.0
37.9
15.4
4.1
28.4
31.6
79.4
10.8
2.7
(1.9)
11.6
491.4

(0.8)
490.6

2016
Var
15.3
(22.8)
(2.9)
1.0
(6.1)
(2.1)
(10.2)
(27.8)
12.4
0.7
8.9
(5.5)
19.5
0.1
(2.7)
2.6
5.4
17.0
58.4
(0.5)
0.0
(21.0)
(14.6)
(0.3)
(1.8)
(0.4)
(38.5)
(1.1)
0.2
(23.4)
(5.8)
(1.2)
(31.2)
2.8
(1.5)
(1.9)
(0.6)
(39.7)

(0.3)
(40.0)

CIR Filing
Plan
67.4
(12.6)
8.9
(4.8)
5.3
14.2
16.9
95.3
29.4
21.4
35.3
28.6
81.6
1.4
4.2
1.4
6.8
23.4
233.5
1.1
44.7
23.2
1.8
70.7
9.6
3.3
79.1
15.1
0.5
107.6
5.9
5.7
11.6
518.8

(1.0)
517.7

Actual

2017
Var

67.7
(27.6)
9.0
(6.4)
2.1
16.8
17.4
79.0
28.2
16.8
54.3
11.6
80.7
3.1
4.9
5.7
9.9
51.0
266.1
34.5
17.2
0.8
0.3
0.6
53.3
9.0
3.7
48.6
48.3
0.0
109.5
12.5
(8.8)
(0.0)
3.7
511.6

0.2
(15.0)
0.1
(1.6)
(3.2)
2.6
0.5
(16.4)
(1.2)
(4.6)
19.0
(17.0)
(0.9)
1.7
0.7
4.3
3.1
27.6
32.6
(1.1)
(10.2)
(6.0)
0.8
0.3
(1.1)
(17.4)
(0.5)
0.4
(30.6)
33.1
(0.5)
1.9
6.7
(14.5)
(0.0)
(7.8)
(7.2)

(3.2)

(2.1)

508.4

(9.3)

CIR Filing
Plan
81.1
(13.6)
7.7
(3.5)
3.4
14.6
15.3
104.9
32.7
21.8
36.4
35.7
87.3
1.9
2.8
0.8
6.9
25.9
252.1
2.3
0.7
38.6
21.7
1.8
65.1
2.1
3.8
28.3
0.1
34.4
4.7
6.2
10.8
467.4

(2.1)
465.2

Actual
59.5
(37.6)
12.5
(9.9)
0.0
16.2
24.8
65.5
26.9
14.7
55.5
19.0
83.1
2.6
2.1
1.8
9.0
35.7
250.3
59.4
12.2
0.8
0.0
(0.0)
72.4
6.3
4.7
55.4
32.2
0.4
98.9
9.8
0.9
10.7
497.8

(1.2)
496.6

2018
CIR Filing
Plan

Var
(21.6)
(24.0)
4.8
(6.4)
(3.4)
1.6
9.5
(39.4)
(5.8)
(7.1)
19.1
(16.8)
(4.2)
0.7
(0.7)
1.1
2.1
9.8
(1.9)
(2.3)
(0.7)
20.8
(9.5)
0.8
0.0
(1.8)
7.4
4.2
0.9
27.0
32.1
0.4
64.5
5.1
(5.3)
(0.1)
30.5

0.9
31.4

76.0
(15.7)
6.5
(2.3)
2.2
16.6
12.4
95.8
33.8
22.0
37.7
39.8
105.7
2.4
0.9
6.9
26.8
275.9
3.4
0.7
23.9
22.7
1.8
52.6
2.2
3.7
28.3
34.2
4.9
6.6
11.5
470.0

(3.2)
466.8

Bridge
85.5
(40.6)
25.5
(17.9)
8.0
17.3
23.0
100.8
40.0
18.9
58.4
19.7
70.0
0.2
1.4
0.1
2.3
18.4
229.4
15.5
(9.6)
0.3
30.6
4.0
0.6
41.4
2.1
3.3
64.6
70.0
6.0
0.3
6.3
447.8

2019
Var
9.4
(24.9)
19.0
(15.6)
5.8
0.7
10.7
5.0
6.1
(3.1)
20.8
(20.1)
(35.7)
(2.2)
1.4
(0.8)
(4.5)
(8.4)
(46.5)
12.1
(9.6)
(0.4)
6.6
(18.7)
0.6
(1.8)
(11.2)
(0.0)
(0.4)
36.3
35.8
1.1
(6.4)
(5.2)
(22.3)

(13.1)

(9.9)

434.7

(32.1)

CIR Filing
Plan
67.7
(17.4)
6.5
(2.2)
2.2
20.8
14.7
92.3
39.3
22.6
39.0
35.4
107.6
3.9
0.6
6.0
32.8
287.3
4.1
0.7
48.1
25.4
1.8
80.2
2.1
3.9
24.3
30.3
5.0
7.1
12.1
502.2

(3.9)
498.3

Bridge
81.4
(43.8)
21.2
(12.9)
3.4
21.6
26.1
97.1
44.4
29.8
57.1
23.7
71.4
2.7
1.5
5.0
17.8
253.4
19.7
(17.7)
0.3
32.8
6.7
41.8
2.5
3.3
34.4
40.2
4.0
(1.6)
2.4
434.9

(9.3)
425.7

Var
13.6
(26.3)
14.8
(10.7)
1.3
0.8
11.4
4.8
5.1
7.2
18.0
(11.7)
(36.2)
(3.9)
2.7
0.9
(0.9)
(15.0)
(33.9)
15.6
(17.7)
(0.4)
(15.3)
(18.7)
(1.8)
(38.4)
0.4
(0.6)
10.1
9.9
(1.0)
(8.7)
(9.7)
(67.2)

(5.4)
(72.7)


## Capital Programs Table

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<th>2016</th>
<th>2017</th>
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<td>MIFRS</td>
<td>MIFRS</td>
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<td>66.8</td>
<td>51.6</td>
<td>53.5</td>
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<td>Customer Connections Capital Contribution</td>
<td>(28.4)</td>
<td>(27.7)</td>
<td>(16.9)</td>
</tr>
<tr>
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<td>5.0</td>
<td>10.6</td>
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<tr>
<td>Externally Initiated Plant Relocations &amp; Expansion Capital Contribution</td>
<td>(1.3)</td>
<td>(4.8)</td>
<td>(8.5)</td>
</tr>
<tr>
<td>Generation Protection, Monitoring, and Control</td>
<td>-</td>
<td>-</td>
<td>2.1</td>
</tr>
<tr>
<td>Load Demand</td>
<td>5.5</td>
<td>14.9</td>
<td>9.8</td>
</tr>
<tr>
<td>Metering</td>
<td>15.5</td>
<td>13.1</td>
<td>24.2</td>
</tr>
<tr>
<td><strong>System Access Total</strong></td>
<td>61.7</td>
<td>52.1</td>
<td>75.1</td>
</tr>
<tr>
<td>Area Conversions</td>
<td>44.0</td>
<td>34.1</td>
<td>35.3</td>
</tr>
<tr>
<td>Network System Renewal</td>
<td>6.8</td>
<td>15.7</td>
<td>12.8</td>
</tr>
<tr>
<td>Reactive and Corrective Capital</td>
<td>38.5</td>
<td>49.2</td>
<td>42.5</td>
</tr>
<tr>
<td>Stations Renewal</td>
<td>6.4</td>
<td>4.8</td>
<td>22.0</td>
</tr>
<tr>
<td>Underground System Renewal - Downtown</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Underground System Renewal - Horseshoe</td>
<td>83.1</td>
<td>84.5</td>
<td>98.5</td>
</tr>
<tr>
<td>Overhead Infrastructure Relocation</td>
<td>3.8</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>SCADAMATE R1 Renewal</td>
<td>5.1</td>
<td>4.1</td>
<td>2.9</td>
</tr>
<tr>
<td>PILC Piece Outs &amp; Leakers</td>
<td>8.9</td>
<td>3.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Underground Legacy Infrastructure</td>
<td>7.0</td>
<td>8.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Overhead System Renewal</td>
<td>60.8</td>
<td>65.6</td>
<td>40.5</td>
</tr>
<tr>
<td><strong>System Renewal Total</strong></td>
<td>264.4</td>
<td>271.4</td>
<td>264.1</td>
</tr>
<tr>
<td>Energy Storage Systems</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Network Condition Monitoring and Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overhead Momentary Reduction</td>
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<td>-</td>
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<td>Stations Expansion</td>
<td>20.6</td>
<td>106.4</td>
<td>64.8</td>
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<td>System Enhancements</td>
<td>4.1</td>
<td>19.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Handwell Upgrades</td>
<td>7.8</td>
<td>1.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Polymer SMD-20 Renewal</td>
<td>1.6</td>
<td>2.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Design Enhancement</td>
<td>0.0</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>System Service Total</strong></td>
<td>34.1</td>
<td>130.3</td>
<td>73.2</td>
</tr>
<tr>
<td>Facilities Management and Security</td>
<td>21.3</td>
<td>17.9</td>
<td>8.7</td>
</tr>
<tr>
<td>Fleet and Equipment</td>
<td>2.9</td>
<td>3.7</td>
<td>4.5</td>
</tr>
<tr>
<td>IT/OT Systems</td>
<td>21.6</td>
<td>40.6</td>
<td>28.2</td>
</tr>
<tr>
<td>Control Operations Reinforcement</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Operating Centers Consolidation Plan</td>
<td>28.5</td>
<td>67.5</td>
<td>67.6</td>
</tr>
<tr>
<td>Program Support</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>General Plant Total</strong></td>
<td>74.3</td>
<td>129.8</td>
<td>109.0</td>
</tr>
<tr>
<td>AFUDC</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.2</td>
<td>1.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Miscellaneous Capital Contribution</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td>(3.4)</td>
</tr>
<tr>
<td><strong>Other Total</strong></td>
<td>0.8</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>435.3</td>
<td>584.3</td>
<td>522.3</td>
</tr>
</tbody>
</table>

Less Renewable Generation Facility Assets and Other Non Rate-Regulated Utility Assets (input as negative)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2.0)</td>
</tr>
</tbody>
</table>

**Total**

<table>
<thead>
<tr>
<th></th>
<th>435.3</th>
</tr>
</thead>
</table>
2B-Staff-75: Appendix E

<table>
<thead>
<tr>
<th>Question</th>
<th>Name of the project</th>
<th>Type of project/brief description of the project</th>
<th>Year the project was originally forecasted to go in-service</th>
<th>Year the project went in-service or is now forecasted to go in-service</th>
<th>Originally plan budget for the project (in $ millions)</th>
<th>Actual cost of the project or revised forecasted cost (in $ millions)</th>
<th>Explanation for any variance in cost if actual/revised forecast is +/- 5% of the original budget amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Expansion of Runnymede TS and Reconductoring of 115kV Transmission Circuits K3W, K31W, K31W and K12K</td>
<td>The project consists of the expansion of Runnymede TS by installing two new 50/83MVA transformers and upgrading the KxW Transmission Corridor to supply the expanded Runnymede TS and maintain the reliability of the transmission supply to the area.</td>
<td>2017</td>
<td>2018</td>
<td>33.0</td>
<td>51.0</td>
<td>Original Class C estimate for the circuit re-conductoring work was based on a project that did not include: - Replacement of steel members (required on 90% of structures) in the 10km corridor - Construction complexities in working in a congested corridor in City of Toronto - More complex outage requirements at Manby, Runnymede and Wiltshire</td>
</tr>
<tr>
<td>b)</td>
<td>Toronto Midtown Transmission Reinforcement Project</td>
<td>The project involves replacing, reconfiguring and installing additional transmission circuits that are at end of life to address overloading of the existing transmission lines between Leaside TS and Bridgman TS. This will also provide capacity for future load growth.</td>
<td>2016</td>
<td>2019</td>
<td>20.0</td>
<td>20.0</td>
<td>As a result of an environmental and engineering study and engineering, it was recommended that a deep tunnel option would solve the congestion issues in the originally proposed rail corridor and city streets along the route which increased the cost of the project.</td>
</tr>
<tr>
<td>c)</td>
<td>Copeland Transformer Station - Phase 1</td>
<td>Enterprise Resource Planning</td>
<td>As discussed in the (2015-2019 DSP Exhibit 2B, E8.6), the utility detailed its need to replace the legacy system, Ellipse, in favour of a modern application to address significant reliability and cybersecurity risks.</td>
<td>The OCCP was a real-estate initiative from 2014 to 2018, intended to: (i) ensure security of tenure at major crew-supporting operating centers; (ii) ensure the uninterrupted continuation of critical functions; and (iii) achieve permanent significant cost savings for ratepayers.</td>
<td>Operating Center Consolidation Program</td>
<td>Radio Project</td>
<td>Telecom Program</td>
</tr>
<tr>
<td>d)</td>
<td></td>
<td>As discussed in the 2015-2019 DSP (Exhibit 2B, E8.7), the voice radio system is critical to Toronto Hydro’s ability to safely and effectively deliver its planned capital and maintenance programs and to respond to trouble calls in a safe, timely and efficient manner.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>As discussed in the 2015-2019 DSP (Exhibit 2B, E8.22), this program reviews and improves the telecommunications system by identifying gaps in the communication service platform</td>
</tr>
<tr>
<td>e)</td>
<td></td>
<td>As discussed in the 2015-2019 DSP (Exhibit 2B, E6.22), this program renews and improves the telecommunications system by identifying gaps in the communication service platform</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*EB-2007-0680 (2008 COS) D2_T01_S01*
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 76:

Reference(s): Exhibit 2B, Section E4, pp. 5-6
Exhibit 9, Tab 1, Schedule 1, p. 32

Preamble:
Toronto Hydro notes that there is a $46.5 million cost variance with respect to the Operating Centre Consolidation Program (OCCP) during the 2015-2019 period.

Toronto Hydro notes that there is an $18.3 million cost variance with respect to the Information Technology (IT) / Operational Technology (OT) program during the 2015-2019 period (Exhibit 2B / Section E4 / pp. 5-6).

a) Please provide a detailed breakdown of the cost variance for the OCCP program for the 2015-2019 period (Exhibit 2B / Section E4 / pp. 5-6).

b) Please provide a breakdown, by property, of net gains from sales that is proposed to be returned to customers as part of the current application. Please advise whether all of these sales are included in the credit balance in the OCCP variance account or if there are property gains from sales that are being disposed separate from the account. Please explain fully.

c) Please provide a detailed breakdown of the cost variance for the IT/OT program for the 2015-2019 period (Exhibit 2B / Section E4 / p. 6).

Panel: (a) Distribution System Capital and Maintenance; (b) Rates and CIR Framework; (c) & (d) General Plant, Operations, and Administration
d) With respect to the Enterprise Resource Planning (ERP) system (which forms part of the IT/OT program), please provide a detailed breakdown of the cost overruns related to this project (Exhibit 2B / Section E4 / p. 6).

RESPONSE:

a) Please see Table 1.

Table 1: Summary of Cost Variance for the OCCP Program for 2015-2019 Period ($M)

<table>
<thead>
<tr>
<th>Variance Cause</th>
<th>Value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>High level scope to detailed design</td>
<td>$19.0</td>
<td>Variance attributable to the move from the high level planning estimates that formed the basis of the OCCP cost estimate to the final detailed designs.</td>
</tr>
<tr>
<td>Design considerations</td>
<td>$18.9</td>
<td>Unforeseen changes in scope resulting from site conditions and/or inspections.</td>
</tr>
<tr>
<td>Ontario Building Code requirements and permit approval process</td>
<td>$5.9</td>
<td>Required building/structural changes to meet legislative requirements including site plan approvals.</td>
</tr>
<tr>
<td>Environment, health and safety related improvements</td>
<td>$2.7</td>
<td>Required improvements to meet health and safety standards.</td>
</tr>
<tr>
<td>Total Variance</td>
<td>$46.5</td>
<td></td>
</tr>
</tbody>
</table>

High Level to Detailed Design Estimates

The largest contributing factor to the variance experienced in OCCP was the ordinary refinement of cost estimates as the OCCP project moved from the high level to detailed design stage. This accounted for $19 million of the $46.5 million total variance. In developing the estimated costs for OCCP, Toronto Hydro relied primarily on high level planning estimates with the expectation that these estimates would be necessarily refined as the project moved from high level planning to execution. The
high level estimates did not include job-specific considerations, which lead to an
increase in the final cost of a project.

Examples of unforeseen considerations that were not known during the original
scoping exercise include: various storm drainage pipes that were found to be
collapsed when they were uncovered; Roof top HVAC units were expected to be re-
used but they were not sized appropriately for the new office spaces; and the canopy
at 500 Commissioners was intended to support the data center power feeds. Once
construction began, it was discovered that many of the structural supports fatigued
due to ice build-up. All of these supports had to be inspected and replaced.

Design Considerations

The second largest cause of the variance was attributable to site-specific design
considerations resulting from inspections or site visits. This accounted for $18.9
million of the total variance. These findings necessitated updated asset configurations
compared to what was originally anticipated.

For instance, the existing roofs at 715 Milner and 71 Rexdale were initially intended to
remain in place and patched as necessary. The 71 Rexdale roof membrane
deteriorated more than expected during construction because of the roof lift,
penetrations, equipment and material staging areas and increased foot traffic.
Replacing it during construction provided efficiencies, deferred future investment and
allowed the utility to function without interruptions in a new building.

Ontario Building Code Requirements and Permit Approvals

An additional $5.9 million in costs were incurred in order to meet legislative
requirements to obtain approvals for occupancy and permits for construction. For
Instance, the 715 Milner employee parking lot was planned for expansion in order to better utilize the south parking area for the outside yard and storage area. Due to the City of Toronto’s site plan control requirements, Toronto Hydro was not able to expand to the east (as originally planned). This resulted in the unanticipated requirement to build a yard in the west side of the facility.

Environmental and Safety Standards

An additional $2.7 million was required to meet environmental, health and safety standards. Some of the required improvements included lead paint removal and asbestos abatement at 71 Rexdale and extended generator rentals due to an extended Ministry of Environment permit approval process.

b) Table 2 provide the requested information. For more details about the proposed dispositions, please refer to Exhibit 9, Tab 1, Schedule 1.

Table 2: Property Sales - Net Gain and Disposition ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>OCCP Variance Account</th>
<th>Separate Variance Account</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5800 Yonge 28 Underwriters Total</td>
<td>50/60 Eglinton</td>
</tr>
<tr>
<td>Net gain, net of tax</td>
<td>98.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Tax Savings after gross-up</td>
<td>35.5</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Actual net gain before carrying charges</strong></td>
<td>134.1</td>
<td>8.1</td>
</tr>
<tr>
<td>Carrying Charges</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Total for Clearance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forecasted total disposition up to 2018</td>
<td>(60.4)</td>
<td>(12.1)</td>
</tr>
<tr>
<td><strong>Proposed Dispositions in Current Filing</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
c) Please see Table 3, below, for detailed breakdown and explanation of variances for the IT/OT Program.

Table 3: Cost variance for IT/OT Program for the 2015-2019 period ($ Millions)

<table>
<thead>
<tr>
<th>Program</th>
<th>CIR Plan</th>
<th>CIR Actual</th>
<th>Variance</th>
<th>Variance Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP</td>
<td>51.3</td>
<td>62.8</td>
<td>11.5</td>
<td>Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-71.</td>
</tr>
<tr>
<td>IT Hardware &amp; Software</td>
<td>117.7</td>
<td>119.5</td>
<td>1.8</td>
<td>Increased cost resulting from Canadian to US dollar exchange rate, change in hardware requirements due to standards changes and additional requirements for components. There were also slightly higher than anticipated software program costs to maintain and improve the security and reliability of the IT systems.</td>
</tr>
<tr>
<td>Voice Radio System</td>
<td>20.4</td>
<td>21.8</td>
<td>1.4</td>
<td>Variance attributable to the additional supporting infrastructure that was required to deploy the radio system, namely facilities work, power backup (UPS/generators), HVAC and redundant fiber-optic telecom links for the 10 radio antenna bearing high-sites that enable the P25 radio system to function.</td>
</tr>
<tr>
<td>Distribution System Comm.</td>
<td>16.0</td>
<td>19.7</td>
<td>3.7</td>
<td>$2.6 million of this variance is attributable to the added scope of completing the necessary facilities, telecom, and IT infrastructure investment to ensure business continuity in the event of a power disruption. The remaining $1.1 million of variance is attributable to higher than forecasted fiber-optic plant installation costs as well as the deployment of a more advanced, secure and future-proof telecom technology than what was available at the time of the original filing.</td>
</tr>
<tr>
<td>Total1</td>
<td>205.3</td>
<td>223.8</td>
<td>18.5</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Totals may not add due to rounding.

d) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-71.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 77:

Reference(s): Exhibit 2B, Section E4, pp. 3-4

a) Toronto Hydro completed a higher amount of overhead system renewal in 2015 and 2016 due to declining reliability in 2013 and 2014. Please explain the reasons for the declining reliability in 2013 and 2014 (Exhibit 2B / Section E4 / p. 3).

b) Due to the higher forecast spending on system renewal in 2015 and 2016, Toronto Hydro reduced spending in 2017-2019 to remain in alignment with the original 2015-2019 forecast for system renewal capital expenditures (Exhibit 2B / Section E4 / p. 4). Please advise whether this means that Toronto Hydro has moved spending out of the 2015-2019 period and into the 2020-2024 period. If so, does this mean that Toronto Hydro will not meet its 2015-2019 proposed plan for system renewal.

RESPONSE:

a) In 2013, reliability performance on the system as a whole declined due to an increase in adverse weather impacts (e.g. 2013 ice storm) and tree contacts, which directly affected the overhead distribution system and were the main contributors to the decline in SAIFI and SAIDI. Please refer to Figures 13 and 14 in Exhibit 1B, Tab 2, Schedule 4 for the reliability impact of weather in 2013. In 2014, overhead switch failures and a slight increase in poles and pole hardware failures resulted in a decline in SAIFI and SAIDI.
Please refer to Exhibit 1B, Tab 2, Schedule 4, for further discussion of Toronto Hydro’s reliability performance across various categories in 2013 and 2014.

b) While there are year-over-year fluctuations between the planned and actual system renewal expenditures over the 2015-2019 period, the total five year expenditure is within 1 percent of the planned five year total. As a result, Toronto Hydro is on track to meet its planned capital investment for System Renewal over the five year period. Please refer to Exhibit 2B, Section E4, Table 1 for a summary of Toronto Hydro’s capital expenditures.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 78:

Reference(s): Exhibit 2B, Section E5.1, pp. 12-13, 16-17

a) Please provide the forecast from Toronto Hydro’s last rebasing proceeding for
generation connections and capacity for the 2015-2019 period. Please provide a
comparison to the amount of connections and capacity that has been actually
placed in-service or is expected to be placed in service in those years (Exhibit 2B /
Section E5.1 / pp. 12-13).

b) Please show the calculation supporting the 46% average capital contribution that
has been applied to determine the net customer connection capital expenditures
for the 2020-2024 period (Exhibit 2B / Section E5.1 / p. 16).

c) Please explain why the capital contributions for generation connections were
higher in some years than the costs (Exhibit 2B / Section E5.1 / p. 17).

RESPONSE:

a) Please see Table 1 and Table 2 below. Please note that Toronto Hydro does not
currently have this data finalized for 2018.

<table>
<thead>
<tr>
<th>Type</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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</thead>
<tbody>
<tr>
<td>Renewable / FIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forecast</td>
<td>424</td>
<td>300</td>
<td>296</td>
<td>300</td>
<td>312</td>
</tr>
<tr>
<td>Actual</td>
<td>326</td>
<td>250</td>
<td>201</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Type</td>
<td>2015</td>
<td>2016</td>
<td>2017</td>
<td>2018</td>
<td>2019</td>
</tr>
<tr>
<td>-------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Natural Gas / CHP</td>
<td>Forecast</td>
<td>6</td>
<td>13</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>Diesel / Other</td>
<td>Forecast</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Forecast</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Actual</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: All figures based on date of electrical connection.

Table 2: 2015-2019 Generation Capacity (MW) Breakdown

<table>
<thead>
<tr>
<th>Type</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable / FIT</td>
<td>Forecast</td>
<td>41.9</td>
<td>23.9</td>
<td>25.8</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>27.5</td>
<td>14.7</td>
<td>10.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Natural Gas / CHP</td>
<td>Forecast</td>
<td>35.5</td>
<td>28.2</td>
<td>27.3</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>9.8</td>
<td>0</td>
<td>5.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Diesel / Other</td>
<td>Forecast</td>
<td>32.9</td>
<td>18.0</td>
<td>8.0</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
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<td>10.1</td>
<td>6.5</td>
<td>11.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Forecast</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

b) Toronto Hydro applied a 5-year (i.e. 2013-2017) weighted average calculation to arrive at the capital contribution percentage.

First, actual expenditures and contributions for the most recent five historic years (i.e. 2013-2017) were escalated to 2020 dollars using an inflation rate of 2%. Please see the escalation equation, historic figures (Table 3), and escalated figures in 2020 dollars (Table 4).

\[
Future\ Value = Present\ Value \times (1 + i)^n
\]
Table 3: Spend ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td>77.1</td>
<td>65.6</td>
<td>68.3</td>
<td>67.1</td>
<td>58.7</td>
</tr>
<tr>
<td>Customer Contributions</td>
<td>(23.6)</td>
<td>(13.5)</td>
<td>(35.7)</td>
<td>(27.4)</td>
<td>(36.6)</td>
</tr>
</tbody>
</table>

Table 4: Escalated Spend ($ Millions in 2020 amounts)

<table>
<thead>
<tr>
<th></th>
<th>2013 (1)</th>
<th>2014 (2)</th>
<th>2015 (3)</th>
<th>2016 (4)</th>
<th>2017 (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross ($G_i$)</td>
<td>88.5</td>
<td>73.9</td>
<td>75.4</td>
<td>72.6</td>
<td>62.2</td>
</tr>
<tr>
<td>Customer Contributions ($CC_i$)</td>
<td>(27.1)</td>
<td>(15.2)</td>
<td>(39.4)</td>
<td>(29.7)</td>
<td>(38.8)</td>
</tr>
</tbody>
</table>

Second, weights were assigned to each year as shown in Table 5 below. The weights are linear in nature, cumulatively add up to 100% over the 5-year period, and are designed to place more emphasis on recent years.

Table 5: Weights ($w_i$)

<table>
<thead>
<tr>
<th>Year</th>
<th>2013 (1)</th>
<th>2014 (2)</th>
<th>2015 (3)</th>
<th>2016 (4)</th>
<th>2017 (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight ($w$)</td>
<td>6.7%</td>
<td>13.3%</td>
<td>20.0%</td>
<td>26.7%</td>
<td>33.3%</td>
</tr>
</tbody>
</table>

Third, the capital contribution ratio was calculated using the formula below.

$$Capital \ Contribution \ Ratio = \frac{w_1 \times CC_1 + w_2 \times CC_2 + w_3 \times CC_3 + w_4 \times CC_4 + w_5 \times CC_5}{w_1 \times G_1 + w_2 \times G_2 + w_3 \times G_3 + w_4 \times G_4 + w_5 \times G_5}$$

Please note that for the 2020-2024 forecast amounts, Toronto Hydro applied other allocations to the gross customer connections forecast.

c) Please refer to footnote 24 on page 17 of Exhibit 2B, Section E5.1.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 79:
Reference(s): Exhibit 2B, Section E5.4, pp. 6, 14, 16-17

a) Please explain why there are no costs recorded in 2015 and 2016 in Table 5 for large customer and interval metering (Exhibit 2B / Section E5.4 / p. 14). Please provide the response in the context of the 74 and the 186 large user meters installed during 2015 and 2016 respectively (Exhibit 2B / Section E5.4 / p. 6).

b) Please advise whether in accordance with Toronto Hydro’s selected option (Option 2 - replace meters over a 6-year period – 2022-2027), any meters would be replaced prior to their end of useful lives (Exhibit 2B / Section E5.4 / p. 16).

c) Please provide the total non-adjusted cost of Option 4 (replace meters over a 4-year period (2024-2027)) and advise how much of that capital expenditure would come into service in the 2020-2024 period (Exhibit 2B / Section E5.4 / p. 17).

RESPONSE:

a) In 2015 and 2016, there were 74 and 186 large user ION meters installed respectively. In 2016 and 2016, the costs for these meters were tracked under the Residential and Small C&I meter replacement segment. Starting in 2017, the costs for installation of large user ION meters were allocated and tracked under the Large Customer and Interval Metering segment.
b) Toronto Hydro does not plan on replacing meters prior to their end of useful life. As stated in Exhibit 2B, Section E5.4, p. 16, “[m]eters would start being replaced as soon as or shortly after they hit the end of their useful life of 15 years, and the replacement schedule for any given meter would generally take place over the two years between their end of useful life and their seal expiry year.”

c) The adjustment in Exhibit 2B, Section E5.3, at page 17 refers to the net present value adjustment that Toronto Hydro applied to the meter replacement options. The unadjusted cost of Option 3 (replace meters over a four year period) is $142.4 million. Please see Table 1 below for the annual timing of the spending for this option.

Table 1: Option 3: Unadjusted Costing

<table>
<thead>
<tr>
<th></th>
<th>Unadjusted Costing ($ Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>4 Year Meter</td>
<td>0.17</td>
</tr>
</tbody>
</table>
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 80:

Reference(s): Exhibit 2B, Section E6.1, pp. 21, 25, 27-28

1. a) Please provide the total forecast capital expenditures necessary to convert all rear lot served customers (Exhibit 2B / Section E6.1 / p. 21). Please provide the expected final year in which all rear lot configurations will have been converted based on Toronto Hydro’s proposal in this proceeding and provide the total number of rear lot configurations expected to be remaining at the end of 2019 and 2024.

2. b) Please provide a detailed calculation of the average cost per customer for rear lot conversions (including the inflation, engineering and support costs) (Exhibit 2B / Section E6.1 / p. 21). Please reconcile this amount to the total capital expenditures forecast for this category of spending for 2020-2024 period.

3. c) Please provide a detailed calculation of the average cost per customer for box pole construction conversions (including the inflation, engineering and support costs) (Exhibit 2B / Section E6.1 / p. 25). Please reconcile this amount to the total capital expenditures forecast for this category of spending for the 2020-2024 period.

4. d) For rear lot conversions, please provide an estimate of the cost of Option 3 (replace rear lot distribution with overhead front lot distribution) for the 2020-2024 period assuming the same amount of conversions were undertaken (Exhibit 2B / Section E6.1 / pp. 27-28).
RESPONSE:

a) The funding required to convert all rear lot customers by 2020 is approximately $300 million. This figure does not include escalation (i.e. inflation). Based upon a continuation of Toronto Hydro’s proposed spending, all rear lot customers will be converted by the mid-2030s. By the end of 2019, Toronto Hydro forecasts there will be approximately 6,300 customers and by the end of 2024 there will be approximately 3,900 rear lot customers remaining to be converted. Please refer to Exhibit 2B, Section E6.1, Figure 13.

b) The cost per customer within the Rear-lot program is $36,000. 67 percent of the $36,000 is for the civil portion and 33 percent is for the electrical portion. The cost is based on average costs from rear lot projects constructed in 2015-2017. For the 2020-2024 forecast, $36,000 was used as a base multiplier relative to the number of customers.

Table 1: Rear Lot Cost Breakdown

<table>
<thead>
<tr>
<th>Project Area</th>
<th>Phase</th>
<th>Filing Year</th>
<th># of Customers</th>
<th>Cost ($M)</th>
<th>Yearly Cost ($M)</th>
<th>Inflation</th>
<th>Other Allocations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorncrest</td>
<td>Civil</td>
<td>2020</td>
<td>618</td>
<td>14.9</td>
<td>14.9</td>
<td>1.8</td>
<td>2.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Jamestown</td>
<td>Civil</td>
<td>2021</td>
<td>258</td>
<td>6.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thorncrest</td>
<td>Electrical</td>
<td>2021</td>
<td>618</td>
<td>7.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markland Woods</td>
<td>Civil</td>
<td>2021</td>
<td>300</td>
<td>7.2</td>
<td>20.9</td>
<td>2.6</td>
<td>2.9</td>
<td>26.4</td>
</tr>
<tr>
<td>Jamestown</td>
<td>Electrical</td>
<td>2022</td>
<td>258</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markland Woods</td>
<td>Electrical</td>
<td>2022</td>
<td>300</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mount Olive</td>
<td>Civil</td>
<td>2022</td>
<td>83</td>
<td>2.1</td>
<td>19.6</td>
<td>2.9</td>
<td>2.7</td>
<td>25.2</td>
</tr>
<tr>
<td>Martin Grove Gardens</td>
<td>Civil</td>
<td>2022</td>
<td>452</td>
<td>10.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kingsview</td>
<td>Civil</td>
<td>2023</td>
<td>173</td>
<td>4.1</td>
<td>21.8</td>
<td>3.6</td>
<td>3</td>
<td>28.4</td>
</tr>
<tr>
<td>Mount Olive</td>
<td>Electrical</td>
<td>2023</td>
<td>83</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: Box Construction Cost Breakdown

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Poles</td>
<td>631</td>
<td>562</td>
<td>563</td>
<td>581</td>
<td>531</td>
</tr>
<tr>
<td>Costs (Unit Cost of $29,000) ($M)</td>
<td>18.3</td>
<td>16.4</td>
<td>16.3</td>
<td>16.8</td>
<td>15.4</td>
</tr>
<tr>
<td>Inflation ($M)</td>
<td>1.9</td>
<td>2.2</td>
<td>2.5</td>
<td>2.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Other Allocations ($M)</td>
<td>2.5</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Total ($M)</td>
<td>22.7</td>
<td>20.8</td>
<td>21.1</td>
<td>22.0</td>
<td>20.7</td>
</tr>
</tbody>
</table>

### Panel: Distribution System Capital and Maintenance

The program cost per pole within the box construction segment is $29,000. This cost is based on average costs from projects constructed in 2015 to 2017.

Toronto Hydro has not prepared a cost estimate for front-lot overhead as this option is not feasible as noted in previous applications before the Board. (For an example, please see Toronto Hydro’s EB-2012-0064, Exhibit B, Tab 2, Schedule B6, pages 32-37.) Toronto Hydro’s proposed plan is for front-lot underground as described in Exhibit 2B, Section E6.1.5.1.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 81:

Reference(s): Exhibit 2B, Section E6.2, pp. 2, 22, 26, 28, 31-32

a) Toronto Hydro plans to prioritize the replacement of underground transformers that are at risk of failure, which are known to, or at a risk of, containing PCB-contaminated oil (Exhibit 2B / Section E6.1 / p. 2). Please explain how Toronto Hydro will know when all PCB-contaminated equipment has been eliminated as there is no accurate database of this inventory (in the context of Toronto Hydro’s statement that it will prioritize replacement of underground transformers that are at risk of containing PCB-contaminated oil).

b) Please reconcile the statement that 723 switches are at or beyond their useful life as of 2017 (Exhibit 2B / Section E6.2 / p. 26) with the information in Table 8 (Exhibit 2B / Section E6.2 / p. 22).

c) Toronto Hydro states that its 2020-2024 underground circuit renewal budget is based on historical unit cost trends (Exhibit 2B / Section E6.2 / p. 28). Please provide the historical and forecast unit costs for underground cable, transformers and switches. Please show how historical costs have influenced the forecast capital budget.

d) Please provide the total cost of Option 1 (spot replacement of transformers in deteriorated condition at or beyond their useful life) and Option 2 (area rebuilds) for the 2020-2024 period (Exhibit 2B / Section E6.2 / pp. 31-32). Please compare to the total cost of the selected option for the same period.
RESPONSE:

a) Toronto Hydro has developed a full list of “PCB at-risk equipment”.¹ As described in Exhibit 2B, Section E2 at page 36, Toronto Hydro’s strategy is to inspect, test, or replace each and every piece of equipment on that list. As these activities are completed, Toronto Hydro will remove equipment from the list when it no longer contains PCBs (i.e. below 2ppm). Removal of all equipment from the list will be used as the indicator that all PCB-contaminated equipment has been eliminated.

b) The 723 switches at or beyond their useful life (in Exhibit 2B, Section E6.2, at page 26) includes both pad mounted and vault installations whereas Table 8 (in Exhibit 2B, Section E6.2, at page 22) shows data for pad-mounted switches only. Underground Switches age demographic as of 2017 is shown in Figure 20 of Exhibit 2B, Section E6.2, at page 25.

c) Please see Table 1 below.

Table 1: Historical Unit Costs (2015-2017) for Major Units

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable ($/m)</td>
<td>$100</td>
<td>$96</td>
<td>$125</td>
<td>$107</td>
<td>$115</td>
</tr>
<tr>
<td>Transformers ($/unit)</td>
<td>$22,697</td>
<td>$23,091</td>
<td>$20,596</td>
<td>$22,128</td>
<td>$22,767</td>
</tr>
<tr>
<td>Pad-Switch ($/unit)</td>
<td>$83,479</td>
<td>$81,611</td>
<td>$81,798</td>
<td>$82,296</td>
<td>$87,333</td>
</tr>
</tbody>
</table>

Note: The 2020 forecast was based on the 2015-2017 Average and escalated to 2020 dollars using 2% escalation per year. 2021 to 2024 forecasts, which are not shown in the table, were developed using the same escalation.

¹ “PCB at-risk equipment” is defined in Exhibit 2B, Section D.2.2 at page 14, as equipment that (i) is known to contain oil with greater than 2 ppm concentration of polychlorinated biphenyl (“PCB”), or (ii) has an unknown concentration of PCB and was manufactured in 1985 or earlier (and is therefore at a high risk of containing greater than 2 ppm PCBs). Please see the seventh column of Exhibit 2B, Section D2, Table 1 on page 12 for summary statistics.
The forecasted costs were directly influenced by unit costs contained in the table as these were used to estimate the aggregate cost associated with installing cable, transformers, and switches. In addition to the aggregate costs for cable, transformers, and switches, estimated costs for civil elements and other equipment were added to arrive at the overall forecasts.

d) The total cost for the Options 1, 2 and 3 are provided in Table 2. These are total costs for 2020-2024 period based on 2017 costs excluding inflation and other allocations.

Table 2: Costs for Underground Circuit Renewal Options 1, 2 and 3 ($ Millions)

<table>
<thead>
<tr>
<th>Options</th>
<th>2020-2024(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Spot replacement of transformers in deteriorated condition at or beyond their useful life</td>
<td>123.4</td>
</tr>
<tr>
<td>Option 2: Area Rebuilds</td>
<td>469</td>
</tr>
<tr>
<td>Option 3: Area rebuilds and Spot replacement of transformers at or beyond their useful life</td>
<td>349(^2)</td>
</tr>
</tbody>
</table>

Note 1: Costs in this column are 2017 dollars and excludes inflation and other allocations.

Note 2: $460.3 million including inflation and other allocations.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 82:

Reference(s): Exhibit 2B, Section E6.3, pp. 2-3, 29

Preamble:
Toronto Hydro plans to replace 2% of existing paper-insulated lead covered (PILC) cable, 20% of asbestos-insulated lead (AILC) covered cable, and an estimated 15 chamber rebuilds, 24 chamber roof rebuilds and 3 chamber abandonments each year during the 2020-2024 period (Exhibit 2B / Section E6.3 / pp. 2-3).

a) Please explain why the proposed volume of replacement was selected (i.e. 2% of PILC cable, 20% of AILC, and the proposed amount chamber rebuilds) (Exhibit 2B / Section E6.3 / pp. 2-3). Please also explain how Toronto Hydro will determine what sections of cable and which chambers to address first.

b) Please provide the historical costs per circuit km (2015-2017) for PILC cable and AILC cable replacement that support the forecast costs (2020-2024) (Exhibit 2B / Section E6.3 / p. 29). Please explain any major variances in costs per circuit km.

RESPONSE:

a) Toronto Hydro has determined that approximately 2 percent of the PILC population is in a critical state and requires replacement to mitigate reliability impacts caused by cable failure. The replacement of priority PILC cable sections drives the replacement of AILC cables downstream. For a detailed discussion of the multi-faceted analysis
Toronto Hydro undertakes to identify and prioritize only the highest-risk PILC cables for replacement, please refer to Exhibit 2B, Section E6.3.3.1.

The proposed volume and prioritization of cable chamber rebuilds is based on the assets in HI4 or HI5 condition. For a discussion on the proposed number of cable chamber rebuilds for 2020-2024, please refer to Exhibit 2B, Section E6.3.4.2. For a detailed explanation of cable chamber condition, refer to Section E6.3.3.2.

b) The Underground System Renewal – Downtown program did not exist prior to 2020. In the past, Toronto Hydro has replaced or repaired PILC and AILC in small quantities proactively within other capital programs or reactively as required. The scope of work and manner of work execution for these historical replacements would vary – sometimes significantly – from the planned replacements in this program. As a result, it would be inappropriate to use these average historical replacement costs as the sole basis for estimating future costs in this new program. Toronto Hydro’s volumetric costs for this program are based on an analysis of analogous historical projects, combined with additional estimating assumptions and professional judgement.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 83:

Reference(s): Exhibit 2B, Section E6.4, pp. 23, 25-26

a) Please provide the historical (2015-2017) and forecast (2020-2024) costs per unit for automatic transfer switches (ATS) and reverse power breakers (RPB) replacements (Exhibit 2B / Section E6.4 / p. 23). Please explain any major variances in per-unit costs.

b) With respect to network vault renewal, please provide the historical (2015-2017) and forecast (2020-2024) unit costs (Exhibit 2B / Section E6.4 / pp. 25-26). Please explain any major variances in per-unit costs.

RESPONSE:

a) Please see Table 1 below for historical and forecast ATS and RPB unit replacement costs. Per unit costs vary considerably from one project to the next due to site-specific factors including the differing types and ratings of replacement equipment needed to match individual customer requirements.

Table 1: Per Unit Costs for Legacy Network Equipment (ATS & RPB) Renewal

<table>
<thead>
<tr>
<th></th>
<th>2015-2017</th>
<th>2020-2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ per unit</td>
<td>$91,200</td>
<td>$289,300</td>
</tr>
</tbody>
</table>

Note: Due to variances in costs between units and the relatively few units replaced annually, Toronto Hydro has aggregated 2015-2017 replacements in the table above and is providing a minimum, average, and maximum cost per unit.
Panel: Distribution System Capital and Maintenance

b) Please see Table 2 for historical and forecast per unit Network Vault Renewal costs.

Table 2: Per Unit Costs for Network Vault Renewal

<table>
<thead>
<tr>
<th></th>
<th>2015-2017</th>
<th>2020-2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ per unit</td>
<td>Min</td>
<td>Average</td>
</tr>
<tr>
<td>$75,489</td>
<td>$580,118</td>
<td>$2,215,675</td>
</tr>
</tbody>
</table>

Note: Due to variances in costs between units and the relatively few units replaced annually, Toronto Hydro has aggregated 2015-2017 replacements in the table above and is providing a minimum, average, and maximum cost per unit.

As discussed in Exhibit 2B, Section E6.4 at page 25, costs for civil work such as that done in Network Vault Renewal can vary greatly from one unit to the next as a result of factors such as the electrical equipment within the vault and surrounding infrastructure, the location of the vault, and the specific scope of work. For example, costs to fully rebuild a vault may well exceed $1 million, while a roof rebuild may be $0.2 million.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 84:

Reference(s): Exhibit 2B, Section E6.5, pp. 17-18

Toronto Hydro states that it will have spent almost 25% more on overhead system renewal during the 2015-2019 period than planned (Exhibit 2B / Section E6.5 / p. 17) due to increased work volume. Please provide a comparison of the 2015-2019 planned number of overhead unit replacements and actual (or most recent forecast) number of overhead unit replacements in the same format as Table 7 (Exhibit 2B / Section E6.5 / p. 18).

Toronto Hydro states that its 2020-2024 forecast capital expenditures related to overhead system renewal is based on the historical unit cost trends (Exhibit 2B / Section E6.5 / p. 18). Please provide the historical and forecast unit costs for poles, transformers, overhead switches and conductors (per km). Please show how historical costs have influenced the forecast capital budget.

RESPONSE:

a) Toronto Hydro notes that the preamble to the question incorrectly paraphrases the utility’s evidence. It is only in 2015 and 2016 that Toronto Hydro undertook a greater work volume. As noted in Exhibit 2B, Section E6.5, page 18, Toronto Hydro ramped down volumes of work in this program in 2017 through 2019. Please see Table 1 below for the 2015-2019 actual and planned overhead volumes of work.
Table 1: 2015-2019 Overhead Units (Planned vs. Actual/Forecast)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td>3332</td>
<td>3656</td>
<td>1735</td>
<td>2692</td>
<td>1900</td>
<td>1513</td>
<td>1100</td>
<td>1934</td>
<td>2313</td>
<td>550</td>
</tr>
<tr>
<td>Pole Top Transformers</td>
<td>972</td>
<td>940</td>
<td>511</td>
<td>769</td>
<td>478</td>
<td>441</td>
<td>598</td>
<td>575</td>
<td>673</td>
<td>290</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td>294</td>
<td>192</td>
<td>160</td>
<td>167</td>
<td>166</td>
<td>120</td>
<td>154</td>
<td>55</td>
<td>207</td>
<td>35</td>
</tr>
<tr>
<td>Primary Conductor (km)</td>
<td>N/A</td>
<td>155</td>
<td>N/A</td>
<td>179</td>
<td>N/A</td>
<td>123</td>
<td>N/A</td>
<td>70</td>
<td>N/A</td>
<td>63</td>
</tr>
</tbody>
</table>

b) Table 2 below shows the historic unit cost trends of the major overhead assets included in Table 1 in part (a).

Table 2: 2015 -2019 Major Overhead Assets Unit Costs ($)

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>2015 Actual</th>
<th>2016 Actual</th>
<th>2017 Actual</th>
<th>2018 F2 Actual</th>
<th>2019 F Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td>$7,880</td>
<td>$7,538</td>
<td>$6,454</td>
<td>$7,385</td>
<td>$7,533</td>
</tr>
<tr>
<td>Pole Top Transformers</td>
<td>$12,084</td>
<td>$12,220</td>
<td>$10,969</td>
<td>$11,823</td>
<td>$12,059</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td>$21,994</td>
<td>$26,359</td>
<td>$18,336</td>
<td>$24,660</td>
<td>$25,153</td>
</tr>
<tr>
<td>Primary Cables ($/km)</td>
<td>$59,500</td>
<td>$63,200</td>
<td>$60,400</td>
<td>$62,577</td>
<td>$63,829</td>
</tr>
</tbody>
</table>

The 2020-2024 forecasts are based on historical unit costs plus an inflation factor of 2 percent as shown in Table 3 below:

Table 3: 2020-2024 Major Overhead Assets Unit Costs ($)

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td>$7,684</td>
<td>$7,837</td>
<td>$7,994</td>
<td>$8,154</td>
<td>$8,317</td>
</tr>
<tr>
<td>Pole Top Transformers</td>
<td>$12,300</td>
<td>$12,546</td>
<td>$12,797</td>
<td>$13,053</td>
<td>$13,314</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td>$25,656</td>
<td>$26,169</td>
<td>$26,693</td>
<td>$27,227</td>
<td>$27,771</td>
</tr>
<tr>
<td>Primary Cables ($/km)</td>
<td>$65,105</td>
<td>$66,407</td>
<td>$67,735</td>
<td>$69,090</td>
<td>$70,472</td>
</tr>
</tbody>
</table>

1 The Planned units provided for 2018 and 2019 are Toronto Hydro’s most recent forecasts.
2 The 2018 and 2019 unit costs are based on the weighted average of 2015 -2017 unit costs, plus 2% inflation factor.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 85:
Reference(s): Exhibit 2B, Section E6.6, p. 44, p. 60

Preamble:
Toronto Hydro states that spending in the stations renewal program is expected to be less than planned during the 2015-2019 period due to changes in its execution plan. Due to the challenges and delays experienced during the 2015-2019 period, there is a back-log of high priority station projects that need to be completed urgently.

a) Please provide a variance analysis between historical planned and actual (or most recent forecast) for the 2015-2019 period with respect to the number of units replaced for all sub-categories of spending (e.g. TS switchgear, TS outdoor breakers, MS switchgear, etc.) in the stations renewal program. In the same table, provide the variance between historical planned and actual (or most recent forecast) capital expenditures ($) for those same sub-categories of spending.

b) Please provide, at the same level of detail as Table 25 (Exhibit 2B / Section E6.6 / p. 44), the amount of capital expenditures that has been moved from the 2015-2019 period to the 2020-2024 period. Of the total $141.5 million in stations renewal spending for 2020-2024, what percentage is related to capital spending that was originally planned for the 2015-2019 period.

c) Please explain how the unit costs for the DACSCAN remote terminal units (RTUs) and MOSCAD RTUs were calculated (Exhibit 2B / Section E6.6 / p. 60).
**RESPONSE:**

a) Please refer to Table 1.

**Table 1: 2015-2019 Stations Renewal Program Variance Analysis ($ Millions)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expenditure</td>
<td>Units</td>
<td>Expenditure</td>
</tr>
<tr>
<td><strong>TS Switchgear</strong></td>
<td>96.9</td>
<td>9</td>
<td>30.2</td>
</tr>
<tr>
<td><strong>TS Outdoor Breakers</strong></td>
<td>9.1</td>
<td>35</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>MS Switchgear</strong></td>
<td>9.4</td>
<td>11</td>
<td>14.6</td>
</tr>
<tr>
<td><strong>Power Transformer</strong></td>
<td>12.3</td>
<td>24</td>
<td>11.3</td>
</tr>
<tr>
<td><strong>DACSCAN RTU</strong></td>
<td>1.6</td>
<td>6</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>MOSCAD RTU</strong></td>
<td>1.0</td>
<td>22</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>D20 RTU</strong></td>
<td>-</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>New RTU Installations</strong></td>
<td>0.4</td>
<td>7</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Pilot-wire Protection</strong></td>
<td>2.1</td>
<td>9</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Battery and Charger</strong></td>
<td>3.1</td>
<td>67</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>SST</strong></td>
<td>0.3</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Air Compressor Replacements</strong></td>
<td>0.3</td>
<td>6</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Sump Pump Installations</strong></td>
<td>-</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Fire Barrier/Suppression Systems</strong></td>
<td>0.7</td>
<td>3</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Fire Alarm Systems</strong> (^1)</td>
<td>1.0</td>
<td>5</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>TS Outdoor Switch</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New to 2020-2024 Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MS Primary Supply</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New to 2020-2024 Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interstation Control Wiring</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New to 2020-2024 Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>138.2</td>
<td>-</td>
<td>85.3</td>
</tr>
</tbody>
</table>

Note 1: Fire alarm systems were removed from the Stations Renewal program. Please refer to Exhibit 2B, Section 8.2 for further information on capital spending related to stations fire alarm systems.
b) Please refer to Table 2.

Table 2: 2015-2019 Stations Renewal Program Carry-Over Expenditure ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer Stations</td>
<td>74.5</td>
<td>45.6</td>
<td>61%</td>
</tr>
<tr>
<td>Municipal Stations</td>
<td>37.7</td>
<td>6.6</td>
<td>18%</td>
</tr>
<tr>
<td>Control and Monitoring</td>
<td>22.1</td>
<td>1.2</td>
<td>5%</td>
</tr>
<tr>
<td>Battery and Ancillary Systems</td>
<td>7.3</td>
<td>0.9</td>
<td>12%</td>
</tr>
<tr>
<td>Total</td>
<td>141.5</td>
<td>54.3</td>
<td>38%</td>
</tr>
</tbody>
</table>

Note 1: Expenditures are based on Toronto Hydro’s latest estimates and amounts used to develop the 2020-2024 forecast.

As per Table 2 above, 38 percent of the capital spending proposed in 2020-2024 was originally planned for the 2015-2019 period.

c) When available, Toronto Hydro uses historical actual project costs to develop unit costs for future forecasts. As of 2017, Toronto Hydro had attained zero DACSCAN RTU replacements and 13 MOSCAD RTU replacements.

Given that no historical costs were available for DACSCAN RTU replacements at the time of forecast development, the unit costs were developed using estimates. These estimates were determined by subject matter experts during the detailed design phase for replacements planned for 2018, which are slightly smaller in scope than those planned for 2019 onwards. This difference in scope has been accounted for in the unit cost of $0.6 million used for future forecasts.

The MOSCAD unit cost was developed using historical actual project costs for replacements performed between 2015 and 2017. The total cost to replace the 13
MOSCAD RTUs between 2015 and 2017 was $2.6 million dollars, which gives an average unit cost of $0.2 million dollars per MOSCAD RTU replacement.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 86:

Reference(s): Exhibit 2B, Section E6.7, p. 1, p. 10

a) Please list the projects in the reactive and correction capital program that overlap with proactive capital programs. Please explain where the line is drawn as between reactive and proactive capital work.

b) Please further explain the statement that consistent with the 2015-2019 reactive and corrective capital program, the 2020-2024 program includes allowances for streetlight reactive pole replacement, reactive streetlight replacement and streetlight spot improvements (Exhibit 2B / Section E6.7 / p. 1). Please explain what streetlight assets are being referred to and why they form part of rate base.

c) Toronto Hydro estimated the volumes of forecast (2020-2024) meter replacements based on historic failure rates (Exhibit 2B / Section E6.7 / p. 10). Please provide the historical failures rates and explain how those failure rates support the 2020-2024 forecast.

RESPONSE:

a) Toronto Hydro does not have any projects to list that overlap between Reactive and Corrective Capital and proactive capital work. Generally, intervention on all of Toronto Hydro’s assets may occur on either a proactive (i.e. through a planned capital program) or reactive bases (i.e. through the Reactive and Corrective Capital program, described in Exhibit 2B, Section E6.7). The line is drawn on the basis of urgency and
timeline. As discussed in Section E6.7.3.2, at page 7, lines 15-23, interventions that must occur within 6 months, to manage unacceptable (e.g. reliability, safety, environmental) risks occur on a reactive basis. The reactive intervention is requested through a Work Request, discussed on page 9 of E6.7.3.2. If an intervention is not urgent, then the intervention is requested through a scope of work, and considered for future year’s planned work programs, as described in Exhibit 2B, Sections D1.2.2 and D1.2.3 respectively.

At times, an urgent need will arise for intervention on an asset that has been identified in a planned capital project. If the intervention is pressing enough and necessary prior to the completion of the planned project, the intervention will occur as part of the Reactive and Corrective Capital program and the planned project will be modified as necessary. Of all Work Requests (i.e. those on page 9 of E6.7.3.2), Toronto Hydro expects that approximately 10 percent to 20 percent will involve an intervention on an asset that is part of an existing planned capital scope of work.

b) The evidence refers to distribution assets that were formerly part of the street lighting system in the City of Toronto prior to Board’s Decision in EB-2009-0180/0181/0182/0183. These assets are predominantly poles and conductors, serve a distribution purpose, and were brought into Toronto Hydro’s rate base in 2015 pursuant to the Board’s Decision in EB-2014-0116.¹

c) Please refer to Table 1 below for the historic failure rates that Toronto Hydro referenced to develop the 2020-2024 forecast. The forecasts of between 5,500 and 6,000 failures are aligned with failure rates seen in 2016 and 2017 and as noted in

¹ EB-2014-0116, Decision and Order (December 29, 2015)
Exhibit 2B, Section E6.7, at page 10, include a nominal increase over the 2020-2024 period. 2018 failure information is currently being finalized and preliminary data is indicating that 2018 failures exceeded 6,000.

Table 1: Historical Meter Failure Rates

<table>
<thead>
<tr>
<th>Meter Failures (units)</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,362</td>
<td>5,326</td>
<td>5,234</td>
</tr>
</tbody>
</table>
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 87:

Reference(s): Exhibit 2B, Section E7.2, p. 1
Exhibit 2A, Tab 6, Schedule 5

Preamble:
For the energy storage systems (ESS) program, Toronto Hydro provides forecast (2020-2024) rate base of $5.8 million, net costs of $10.5 million, and gross costs of $52.8 million (Exhibit 2B / Section E7.2 / p. 1).

a) Please advise whether the difference between gross costs and net costs is the forecast capital contributions. If not, please explain.

b) Please advise whether the difference between net costs and rate base is the amount that will be recovered through the provincial benefit program. If not, please explain.

c) Please provide the capital expenditures related to each of the three sub-categories of the energy storage system program (grid performance ESS, renewable enabling ESS, and customer-specific ESS) in terms of their contribution towards each of rate base, net costs, and gross costs.

d) Please advise whether there are any OM&A costs (both upfront and ongoing) related to any of the three categories of ESS. If not, please explain. If yes, please provide the amount by category and for each category explain how the OM&A costs are proposed to be recovered (e.g. through the proposed OM&A budget,
directly from customers, etc.). Specifically, please explain why there do not seem to be any OM&A costs proposed to be recovered through the provincial benefit program.

RESPONSE:

a) Yes it is.

b) Yes it is.

c) Please see Table 1 below.

<table>
<thead>
<tr>
<th>ESS Segment</th>
<th>Rate Base (A)</th>
<th>Provincial Benefit (B)</th>
<th>Net Costs (C = A + B)</th>
<th>Capital Contribution (D)</th>
<th>Gross Costs (D + C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Performance</td>
<td>$5.5</td>
<td>$0</td>
<td>$5.5</td>
<td>$0</td>
<td>$5.5</td>
</tr>
<tr>
<td>Renewable Enabling</td>
<td>$0.3</td>
<td>$4.7</td>
<td>$5.0</td>
<td>$0</td>
<td>$5.0</td>
</tr>
<tr>
<td>Customer Specific</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$42.3</td>
<td>$42.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$5.8</strong></td>
<td><strong>$4.7</strong></td>
<td><strong>$10.8</strong></td>
<td><strong>$42.3</strong></td>
<td><strong>$52.8</strong></td>
</tr>
</tbody>
</table>

d) For Customer Driven ESS, OM&A costs are recovered from the customer through the capital contribution. For Grid Performance ESS and Renewable Enabling ESS, no OM&A costs have been explicitly included in the application because these ESS are relatively small in size and the associated OM&A costs are not expected to be material (and will be covered by existing OM&A programs).
As part of the Energy Storage program, Toronto Hydro intends to conduct a detailed benefits analysis. Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-89 (d).
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 88:

Reference(s): Exhibit 2B, Section E7.2, p. 2, p. 17, p. 25, p. 29, p. 38

Preamble:

Toronto Hydro proposed three categories of ESS investments: (a) grid performance; (b) renewable enabling investments; and (c) customer-specific ESS (Exhibit 2B / Section E7.2 / p. 2).

For ESS, Toronto Hydro stated that one of the benefits would be the deferral of conventional infrastructure investments (Exhibit 2B / Section E7.2 / pp. 17, 29).

Toronto Hydro notes “ESS is not always the most economic REI option” and has planned wires solutions in most instances as a result (Exhibit 2B / Section E7.2 / p. 25).

a) Please explain how Toronto Hydro determines the value of deferred capital investment for the purpose of comparing the costs and benefits of its investment options.

b) Please provide a table showing the amounts of deferred capital investment as a result of the ESS projects by category and project.

c) Please provide a table showing the expected timeframe for each deferred investment (i.e. the estimated amount of time until the deferred investment must be made).
d) Please indicate the difference in the estimated costs of the conventional infrastructure investments if those investments were made now versus if they are made later on (having deferred the need for investment with the proposed storage projects).

e) Please indicate whether any results from Toronto Hydro’s existing storage projects were used to estimate the costs and benefits of the storage projects proposed in this application. If yes, please summarize.

f) Given that energy storage is not always the most economic option, please elaborate on how Toronto Hydro determined that energy storage was appropriate in some instances but not other instances, where different forms of grid performance or REI investments are proposed.

g) Please explain the basis for the estimates of the cost of ESS, which appear to be CAD$526 per kWh for deployments in 2018 through 2024, and reconcile with the statement that ESS costs “continue to decline...from US$300 per kWh in 2015 to an expected US$110/kWh in 2024” (Exhibit 2B / Section E7.2 / p. 38).

RESPONSE:

a) Toronto Hydro’s evidence is that ESS investments have the general benefit of deferring investments in generation, transmission, and distribution infrastructure. As set out in the evidence cited in this interrogatory, one of the benefits of ESS projects is that they present a future opportunity for demand response and grid capacity relief, thereby avoiding and/or deferring the need for distribution infrastructure investments. The importance of doing so is highlighted in the Load Demand Program.
at Exhibit 2B, Section E5.3, though that approach has historically been “poles and wires” solutions, whereas ESS is expected to increasingly offer a feasible “non-wires” alternative. The Local Demand Response initiative set out at Exhibit 2B, Section E7.4.3.3 is an example where this deferral has occurred using a non-wires approach at Cecil TS. In assessing the deferral of capital expenditures, both the amount of the deferral and the duration of the deferral are key considerations, as well as engineering and operational considerations related to the suitability of the technological alternatives.

b) This information is not yet known.

c) Please see the response to part (b).

d) Please see the response to part (b).

e) Learnings from Toronto Hydro’s current energy storage projects have helped Toronto Hydro plan the energy storage projects proposed in this segment. Please refer to Exhibit 2B, Section E7.2.3.3, page 24.

f) For proposed energy storage projects, Toronto Hydro evaluates the costs and benefits of the investment. This allows Toronto Hydro to assess the appropriateness of ESS. Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-65 for an example of this analysis. For further information on instances where Grid Performance and Customer-Specific ESS would be chosen, please also refer to pages 14-16 and 26-28 of Exhibit 2B, Section E7.2.
g) The referenced cost of ESS outlined in Bloomberg New Energy Finance (July 5, 2017) is for lithium-ion batteries only. The cost estimates reflected in this program represent the all-in cost of deploying ESS, which includes design and construction, installation, other equipment, and overheads.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 89:

Reference(s):
Exhibit 2B, Section E7.2, pp. 17-28
Exhibit 2A, Tab 6, Schedule 1, pp. 1-5
Ontario Energy Board Act, Section 79.1(1)
Filing Requirements for Electricity Distribution Rate Applications,
Chapter 2, Section 2.2.2.7, pp. 20-21

Preamble:
Toronto Hydro proposes to use energy storage to enable connection of renewable
generation.

Toronto Hydro states that about 830 additional renewable energy generation
connections, totaling 69MW, will be connected to its distribution system between 2019
and 2024. Toronto Hydro anticipates that the pace of these connections will slow with the
end of the FIT program, however, the unit size may be larger due to cost reductions in
solar photovoltaic panels and net metering benefits (Exhibit 2B / Section E7.2 / pp. 17-
18).

The table below summarizes the costs associated with Toronto Hydro’s planned REI
investments over the 2020 to 2024 period (Exhibit 2A / Tab 6 / Schedule 1 / p. 4).
Toronto Hydro stated that it applied the 6% direct benefit, provided by the OEB, to calculate the provincial rate protection amounts (Exhibit 2A / Tab 6 / Schedule 1 / p. 5).

Toronto Hydro notes that renewable enabling ESS can be installed anywhere on a feeder and to avoid additional costs these units will be connected to existing Toronto Hydro assets. However, where such assets or locations are unavailable, Toronto Hydro will install new assets to accommodate the proposed ESS (Exhibit 2B / Section E7.2 / p. 26).

a) Please explain why no REI investment occurred in 2015, 2016 and 2017 (Exhibit 2B / Section E7.2 / p. 23 / Table 13).

b) Please explain how Toronto Hydro’s REI investment plan will change if forecasted renewable generation connections do not materialize.

c) Please explain how Toronto Hydro determined that, of the total $13.6M in renewable enabling investments, $5M should be spent on energy storage projects and $8.6M should be spent on conventional investments. Please discuss with reference to the materiality provision that newly applies to REI funding as a result of the change to section 79.1(1) of the OEB Act.
d) The OEB’s Chapter 2 Filing Requirements note that “distributors will continue to have the option to undertake a more rigorous “detailed” direct benefit assessment based on the criteria set out in the Direct Benefits Report where the distributor believes the standard percentages will not be reflective of the direct benefits of its project(s)” (Chapter 2 Filing Requirements / Section 2.2.2.7 / pp. 20-21). Given energy storage can provide additional system benefits, please explain why recovering 94% of the renewable enabling ESS project costs from provincial ratepayers is still appropriate. Please advise whether Toronto Hydro studied if any additional benefits associated with these storage assets would accrue to Toronto Hydro’s customers. If not, please explain.

e) Please explain the rationale for installing new assets to support renewable enabling ESS when feeders other than those targeted could be used. Please describe the cost consequences of doing so for the project (Exhibit 2B / Section E7.2 / p. 26).

RESPONSE:

a) One of the primary drivers of the 2015-2019 ESS program is to enable renewable energy generation (REG). The need for renewable enabling ESS is highly dependent on the materialization of REG connections in relation to constraints on the system. Spending did not take place in 2015-2017 due evolving REG customer needs. For example, the 2015-2019 ESS program proposed REI investments to dynamically mitigate feeder phase imbalances in order to enable the connection of renewable energy generation (REG). At the time, two existing REG applications had been denied due to phase imbalance constraints. Toronto Hydro proposed to install ESS to mitigate these issues and notified the applicants accordingly. However, due to their
own reasons, the applicants decided to not move forward with the REG installations. In the time since, Toronto Hydro has not received any REG connection applications on the feeders with phase imbalances.

b) Over the course of the plan, Toronto Hydro intends to monitor its renewable generation forecasts to ensure that its REI investment plan remains relevant. If the forecasts do not materialize, Toronto Hydro expects to assess the impacts and make appropriate adjustments to its plan to ensure that it continues to prudently invest in REI.

c) Toronto Hydro forecasts to spend $8.6M over the plan on conventional renewable enabling investments as part of the Generation, Protection, Monitoring, and Control Program (Section E5.5). As noted in the program evidence, this level of investment is necessary to address specific issues and needs, such as short circuit constraints and real time monitoring and control for enabling renewables. By contrast, the renewable enabling investments contained in Energy Storage Program (Section E7.2) are necessary to balance load on certain feeders which cannot accommodate the safe and reliable connection of renewable generation facilities, and which are suitable for ESS investments. The forecasted cost of these investments is $5M over the 2020-2024 period. As shown in the Appendices filed at Exhibit 2A, Tab 6, Schedule 2, the total revenue requirement associated with the proposed renewable enabling investments in each programs is above the utility’s materiality threshold.

d) At this time, Toronto Hydro has not undertaken a more rigorous “detailed” direct benefit assessment. As part of this program, Toronto Hydro intends to undertake a more detailed analysis, based on project specific circumstances and facts, of the
application of the beneficiary pays principle to these investments.

e) As noted in the evidence, wherever it is possible, Toronto Hydro intends to connect the ESS to existing assets. The utility only proposes to install new assets to accommodate the ESS if the existing infrastructure cannot be used due to asset ratings and operational constraints, such as available land space and conflicts with assets of existing utilities (water, communications).
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 90:

Reference(s):

- Exhibit 2B, Section E7.2, pp. 29-42
- Exhibit 2B, Section E7.2, p. 32
- Exhibit 2A, Tab 4, Schedule 1, p. 2
  Affiliate Relationships Code for Electricity Distributors and Transmitters

Preamble:

Toronto Hydro noted that customer reliability needs can be met regardless of whether the ESS is located “in front of the meter” or “behind the meter” and that the physics of ESS confers distribution service benefits to the customer in either scenario. Toronto Hydro further noted that if reliability were the only customer need that Toronto Hydro needed to address, the distribution asset would typically be located in front of the meter. However, to meet the customer’s financial need, Toronto Hydro has to site the ESS behind the meter to achieve peak-shaving (Exhibit 2B / Section E7.2 / p. 32).

Toronto Hydro confirmed that no non-distribution activities are included in its proposed capital plan (Exhibit 2A / Tab 4 / Schedule 1 / p. 2).

The OEB reaffirmed that the provision of behind the meter services and applications that fall within the parameters set out in sections 71(2) or 72(3) of the OEB Act is a non-utility activity (EB-2011-0004 / Report of the Board – Supplemental Report on Smart Grid / p. 5).

In accordance with the OEB’s policies related to activities under those sections, such
activities must be accounted for separately from utility activities and be undertaken on a full cost recovery basis (i.e. not recovered in rates).

The Affiliate Relationships Code for Electricity Distributors and Transmitters sets out requirements to prevent a utility from cross-subsidizing affiliate activities and prevent a utility from acting in a manner that provides an unfair business advantage to an affiliate that is an energy service provider.

a) Please confirm Toronto Hydro’s intention to own behind the meter storage units as distribution assets.

b) In light of the OEB’s determination on behind the meter activities (EB-2011-0004 / Report of the Board – Supplemental Report on Smart Grid / p. 5), and Toronto Hydro’s statement that no non-distribution activities are included in its proposed capital plan (Exhibit 2A / Tab 4 / Schedule 1 / p. 2), please explain why Toronto Hydro believes providing behind the meter ESS services is a distribution activity.

c) Please explain why Toronto Hydro is not delivering these services through an affiliate given that it is a competitive activity.

d) Please advise whether the customers that are being provided behind the meter ESS are aware that this is not a distribution service and, therefore, they are not required to procure this service from Toronto Hydro.

e) Please provide a breakdown of the cost estimates in Table 19 (Exhibit 2B / Section 7.2 / p. 32) assuming this service were provided through an affiliate instead as part of the regulated distribution business. The breakdown should include Toronto
Hydro’s fully-allocated cost to provide services to the affiliate, as well as the estimated fair market value for the service provided by the affiliate to Toronto Hydro, as contemplated in section 2.3 of the Affiliate Relationships Code.

RESPONSE:

a) Confirmed.

b) The ESS infrastructure proposed provides varying degrees of benefit to the distribution system. On the basis that costs should follow benefits, the ESS infrastructure that provides benefits to customers beyond the host site customer are properly classified as part of the distribution system, irrespective of its location in relation to a meter.

The cited Report also states on page 9:

“The Board’s intention is to provide guidance in a holistic manner, recognizing that the modernization of the electricity system is a continuous process with no specific endstate. The circumstances and needs of an electricity distributor’s system and its customers vary significantly across the province. The Board has sought to provide as much guidance as possible to provide a long-term view of electricity network enhancement without prescribing specific investments, technologies, methodologies or standards, or applying procurement requirements and targets.”

Toronto Hydro has pursued these ESS investments and proposes to continue to pursue them, mindful of the guidance in the Report, and in alignment with these core principles set out in the Report. Further, Toronto Hydro respectfully notes that over the past five years since the Report was prepared, there have been significant changes
to technology, customer preferences, and other variables that the sector need to be responsive to. The OEB’s *Strategic Blueprint: Keeping Pace with an Evolving Energy Sector*, issued in December 2017, reflects these changes and the need to innovate to keep pace with them.

c) Toronto Hydro’s ESS program provides benefits to customers through “non-wires” investments (i.e. energy storage systems) that it would otherwise provide using “wires” investments to the distribution system. Accordingly, Toronto Hydro’s view is that these are distribution activities and a distributor is eligible to carry them out. Toronto Hydro recognizes that in some instances customers will choose other means of receiving those benefits, including contracting with non-utility energy services providers. Toronto Hydro facilitates those connections per the normal course in accordance with its obligation to provide access to the system.

d) Where there is a host site customer, it is nearly always if not always the case that the customer contacts Toronto Hydro requesting in general a solution to a desire for greater service quality or more specifically an energy storage system. These large sophisticated customers are aware that Toronto Hydro is not the only option for meeting these needs with respect to behind-the-meter solutions.

e) Toronto Hydro does not have an affiliate that provides energy storage systems to customers.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 91:
Reference(s): Exhibit 2B, Section E7.2, pp. 31-32

Toronto Hydro stated alternatives that entail individualized customer benefits result in costs that would be outside of the utility’s distribution system investment in the normal course. In accordance with the beneficiary pays principle, these costs are fully allocated to the customer who benefits through a capital contribution (Exhibit 2B / Section 7.2 / p. 31).

The table below shows the historical and forecast cost of the Customer-specific ESS (Exhibit 2B / Section 7.2 / p. 32).

<table>
<thead>
<tr>
<th></th>
<th>Bridge</th>
<th>Forecast</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td>Metrolinx ECLRT</td>
<td>9.6</td>
<td>17.7</td>
<td>27.3</td>
</tr>
<tr>
<td>Metrolinx FWLRT</td>
<td>6.0</td>
<td>10.0</td>
<td>16.0</td>
</tr>
<tr>
<td>TTC Arrow Garage</td>
<td>12.3</td>
<td></td>
<td>12.3</td>
</tr>
<tr>
<td>Metrolinx Willowbrook Yard</td>
<td>6.0</td>
<td>2.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Total</td>
<td>9.6</td>
<td>17.7</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>2021</td>
<td>2022</td>
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<tr>
<td></td>
<td>2023</td>
<td>2024</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a) Please advise whether capital expenditures associated with the Metrolinx ECLRT ($27.3 million in 2018 and 2019) were previously approved by the OEB in Toronto Hydro’s 2015-2019 Custom IR proceeding. If not, please explain why Toronto Hydro believes that it was appropriate to undertake this project in the absence of OEB approval.
b) Please provide updated year-to-date expenditures for the Metrolinx ECLRT ESS project.

c) Please provide the amount of the capital contribution received from Metrolinx to date for this project.

d) Please elaborate on Toronto Hydro’s accounting process for any potential over- or under-spending on any of the ESS projects with respect to the payment of capital contributions

RESPONSE:

a) The Metrolinx ECLRT was not included in the 2015-2019 Custom IR application because Toronto Hydro was not aware of the prospect of this ESS investment at the time of the proceeding. In the 2015-2019 Custom IR application, and consistent with the OEB framework for CIR applications more generally, the OEB ordered rates that provide envelope funding for capital expenditures, rather than program or project-specific approvals.

b) The costs incurred in 2017 were immaterial. 2018 financial actuals are not available at this time.

c) There were no capital contributions prior to 2018. 2018 financial actuals are not available at this time.

d) As with all capital contributions, Toronto Hydro requires capital contributions for ESS investments in accordance with the OEB’s Distribution System Code.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 92:

Reference(s): Exhibit 2B, Section E7.2, p. 7, p. 8, p. 13, p. 16

Preamble:
Toronto Hydro proposes to install grid performance ESS on feeders with “key account customers” who have made it clear that increased power quality and reliability is a high priority to them. One of the screening factors Toronto Hydro proposes to use for prioritizing suitable sites for these assets is “benefits to other area customers” (Exhibit 2B / Section E7.2 / p. 13).

Toronto Hydro notes that some customer-specific ESS projects may be reclassified as grid performance ESS (Exhibit 2B / Section E7.2 / p. 16).

a) In the context that a large proportion of benefits associated with the grid performance ESS will accrue to “key account customers”, please explain why Toronto Hydro has not proposed to recover a commensurate proportion of costs associated with this project from these customers.

b) Please advise whether these “key account customers” have expressed a need for higher-than-average power quality or are these customers currently experiencing power quality lower than that which Toronto Hydro provides on average.

c) Please describe the criteria Toronto Hydro uses to classify grid performance ESS projects and customer-specific ESS projects. Please describe the reasons a project may be reclassified from one category to the other.
RESPONSE:

a) Toronto Hydro’s evidence is that each Grid Performance ESS investment will provide benefits to multiple customers. It is not Toronto Hydro’s evidence that a large proportion of benefits of these projects will accrue to Key Account Customers.

The OEB has well-established rules for the allocation of costs of capital investments. Toronto Hydro proposes to apply the rules in the same way irrespective of whether the capital investment uses a “poles and wires” or ESS solution. In some cases, those rules prescribe a capital contribution, but in many others, the rules prescribe that distributors allocate the costs to rate base where they are recovered from a broader pool of customers.

b) Please refer to the customer engagement survey performed by Innovative Research Group, which is filed at Exhibit 1B, Tab 3, Schedule 1. The results detailed in Appendix A to report show that 13 percent of key account customers cited ‘Improve Power Quality’ as one of their priorities.

c) The criteria for Grid Performance ESS investments are outlined in the evidence at Exhibit 2B, Section E7.2, page 13. The principle that underscores the criteria is that multiple customers will benefit from these investments.

The criteria for Customer-specific ESS investment are outlined in Exhibit 2B, Section E7.2, at page 30. The principle that underscores the criteria is that individual customers will benefit from these investments.

A project may be reclassified from one category on the basis of the detailed benefits analysis that Toronto Hydro plans to conduct once all the project details are available.
For example, if the analysis shows that a Grid Performance ESS project is expected to benefit only one customer, that project would be reclassified as a Customer specific ESS investment.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 93:
Reference(s): Exhibit 2B, Section E7.4, p. 1

Preamble:
The stations expansions program is a continuation of the expansion activities described in Toronto Hydro’s 2015-2019 DSP.

a) Please provide a list of the work that was described in Toronto Hydro’s 2015-2019 DSP (including the dollar value) that will be completed during the 2020 – 2024 period.

RESPONSE:
a) The following projects described in 2015-2019 DSP (EB-2014-0016) will be completed during the 2020-2024 period (EB-2018-0165):
   • Copeland TS – Phase 2; and
   • Horner TS Expansion.

Table 1 and Table 2 below show the cost breakdown of these projects as described in Toronto Hydro’s 2015-2019 DSP (EB-2014-0116) and as provided in the 2020-2024 DSP (EB-2018-0165).
Table 1: Copeland TS – Phase 2 – Cost Breakdown ($ Millions)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>EB-2014-0116</td>
<td></td>
<td></td>
<td></td>
<td>24.0</td>
<td></td>
<td>22.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.0</td>
</tr>
<tr>
<td>EB-2018-0165</td>
<td>0.5</td>
<td>1.8</td>
<td>7.8</td>
<td>8.9</td>
<td>29.7</td>
<td>38.8</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td>88.5</td>
</tr>
</tbody>
</table>

Note 1: For EB-2018-0165 costs, 2015-2017 are actuals, 2018-2019 are bridge, and 2020-2024 are forecasts.

Table 2: Horner TS Expansion – Cost Breakdown ($ Millions)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>EB-2014-0116</td>
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<td></td>
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<td></td>
<td></td>
<td>72.0</td>
</tr>
<tr>
<td>EB-2018-0165</td>
<td>0.05</td>
<td>0.3</td>
<td>--</td>
<td>15.0</td>
<td>19.4</td>
<td>10.6</td>
<td>7.8</td>
<td>8.0</td>
<td>8.0</td>
<td></td>
<td>69.15</td>
</tr>
</tbody>
</table>

Note 1: For EB-2018-0165 costs, 2015-2017 are actuals, 2018-2019 are bridge, and 2020-2024 are forecasts.

The cost variance between EB-2014-0116 and EB-2018-0165 for the Copeland TS – Phase 2 project is described below:

1. **EB-2014-0116**
   This forecast only included procurement costs for materials, and did not include additional budget costs (including project management, labour, insurance, legal, etc.).

2. **EB-2018-0165**
   In addition to the point made above, three factors contributed to an increase in forecasted project costs:
   1. **Project Structure**: In Copeland TS – Phase 1, Toronto Hydro used separate contractors for design, supply, and construction. As a result of the Phase 1 experience, a decision was made to use an engineering, procurement, and construction (“EPC”) contract model for Phase 2. This has resulted in significant
increased costs associated with project design, project administration, and
management (both for Toronto Hydro and the EPC firm), audit oversight, and
billing costs.

2) Lessons Learned: In addition to the updated project structure, other lessons
learned during Copeland TS – Phase 1 have increased the costs associated with
Copeland TS – Phase 2 (e.g. difficult site conditions, transformer delivery and
logistics costs, etc.). These lessons have resulted in additional costs forecasted for
Phase 2.

3) Cost Escalation: The most recent forecast provides more realistic cost escalation
factors for both material and labour costs, which have been rising sharply in
Toronto.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 94:

Reference(s): Exhibit 2B, Section E7.4, p. 10, p. 16

Preamble:

Toronto Hydro states that “upgrading these transformers in tandem with Hydro One’s renewal and sustainment plans would alleviate capacity constraints on the system and result in avoided costs of up to $20 million (as shown in Table 12) thus reducing the burden on ratepayers” (Exhibit 2B / Section E7.4 / p. 16)

a) Please advise whether capital contributions made to Hydro One are trued-up to the final cost of the project (Exhibit 2B / Section E7.4 / p. 10). If so, please explain the true-up process and how it affects rate base.

b) Please confirm that the avoided costs referenced reflect costs avoided in Toronto Hydro’s rate base but instead would be included in Hydro One’s rate base (and the associated revenue requirement will be recovered from all ratepayers in Ontario through the Uniform Transmission Rates (UTRs)) (Exhibit 2B / Section E7.4 / p. 16).

RESPONSE:

a) Yes, the capital contributions made to Hydro One are trued-up based on the actual project costs within 180 calendar days after the “Ready for Service Date”. If the


Panel: Distribution System Capital and Maintenance
estimate of a capital contribution paid by Toronto Hydro exceeds the actual capital contribution, Hydro One will refund the difference back to Toronto Hydro. Similarly, if the estimate of a capital contribution paid by Toronto Hydro is less than the actual capital contribution, Toronto Hydro will pay the difference to Hydro One.

The final true-up adjustment amount is considered a capital expenditure and is added or deducted from the closing rate base in the year it is capitalized. Accordingly, it is included in the forward rate base balance.

b) Toronto Hydro confirms that the avoided costs referenced reflect costs avoided in Toronto Hydro’s rate base. Toronto Hydro is not in a position to comment on the treatment of costs within Hydro One’s rate base.

Following Hydro One’s renewal of a transformer, should Toronto Hydro request that Hydro One replace the transformer prior to its end-of-life (for the sole purpose of increasing the transformer’s capacity), Toronto Hydro would incur the cost of the replacement in its entirety. The avoided cost refers to such a scenario. It is in Toronto Hydro rate payers’ best interest that Toronto Hydro make the appropriate incremental upgrades in conjunction with Hydro One renewal and sustainment plans to avoid unnecessary future costs.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 95:

Reference(s): Exhibit 2B, Section E7.4, pp. 22-23, p. 25

a) Please advise whether the Copeland TS – Phase 1 project is now completed and the assets are in-service. If not, please provide the most recent forecast in-service date (Exhibit 2B / Section E7.4 / pp. 22-23).

b) Please provide a more detailed explanation of the events and factors (adverse weather, challenging site conditions, logistical challenges, contractor performance, etc.) that resulted in schedule and spending delays on the Copeland TS – Phase 1 project. Specifically, discuss the impact that contractor performance had on the overall budget (Exhibit 2B / Section E7.4 / pp. 22-23).

c) Please explain the statement “… the overall Copeland TS – Phase 1 budget from project inception to project completion in 2018 has not materially changed.” Please provide the response in the context that the station is projected to cost $15.1 million more than the cost forecasted in the 2015-2019 rates proceeding (Exhibit 2B / Section E7.4 / p. 23).

d) Toronto Hydro states that the Copeland TS – Phase 2 project is expected to be completed by late 2023 or early 2024 (Exhibit 2B / Section E7.4 / p. 23). Please provide the forecast in-service date for the Copeland TS – Phase 2 project that was used for rate base calculation purposes.
e) Toronto Hydro states that it intends to update the Copeland TS – Phase 2 project budget in late 2018 or early 2019 (Exhibit 2B / Section E7.4 / p. 23). Please advise whether Toronto Hydro intends to update its rate base forecast (used in the C-factor calculation) to reflect the updated budget for the project.

f) Please provide breakdown between labour and material costs for the Copeland TS – Phase 2 project (Exhibit 2B / Section E7.4 / p. 25).

RESPONSE:

a) As of December 2018, one of two Hydro One transmission lines and associated HV Switchgear and one Toronto Hydro power transformer (T3) have been energized. Transformer T1, along with all remaining Toronto Hydro and Hydro One equipment is anticipated to be energized in Q1 2019.

b) The following events and factors resulted in schedule and spending delays in Copeland TS – Phase 1:

- **Unusually adverse weather events:** Copeland TS – Phase 1 was under construction (concrete and reinforcing steel placement) when the GTA experienced the ice storm of 2013-14. As well, sustained wind speeds in excess of 50 km/h required suspension of tower crane operations several times during civil construction.

- **Challenging site conditions:** Proximity to the heritage Roundhouse required special care and protection of the adjacent historic building.

Panel: Distribution System Capital and Maintenance
• **Logistical challenges:** There was an inability to secure a large amount of road space for laydown and material delivery. Two constructors (tunnel and station) shared one live lane of Rees St. and were permitted an additional lane of Rees St. outside of rush hour traffic. This required twice daily “bump-out” of perimeter fence. Further, the delivery of two 155 tonne transformer tanks from the port of Toronto to Copeland site required 6 months of planning and engineering studies of the integrity of the structures along the route.

• **Contractor performance:** The general contractor’s UK parent company entered into compulsory liquidation on January 15, 2018. In Canada, the general contractor entered into creditor protection on January 26, 2018. The contractor’s pace of work in the first half of 2018 was thereafter significantly curtailed. This adversely impacted the project schedule, requiring Toronto Hydro to mobilize another general contractor to complete the required work. This incurred additional cost and time. In addition, Hydro One encountered failures with some of the critical components of their HV switchgear near the final stages of their commissioning. Hydro One was initially forecasted to complete their work by Q3 2018. However, as a result of this issue, they are now expected to finish in Q1 2019. Furthermore, the Copeland project will suffer incremental costs due to energization occurring in two separate phases (2018 and 2019) and requiring remobilization of various parties.

c) The latest forecast for the Copeland TS Phase 1 project is $204 million, compared against a $195 million initial budget (EB-2012-0064), or approximately a 4.7 percent increase of total budget, which is not unanticipated for a project of this size and complexity.
The $15.1 million differential arises when the Copeland forecast cited in EB-2014-0116 of $51.6 million in the 2015-2019 period is compared to the budget referenced in EB-2018-0165 of $66.7 million. Approximately $6.1 million of the 2014 spend initially forecasted in EB-2014-0116 was deferred to the 2015-2019 period because of the delay in project progress in the latter half of 2014. The remainder of the $15.1 million differential (i.e. $9 million) is noted in Table 1 below as an increase in spend on Copeland TS – Phase 1 over the original EB-2014-0116 plan. This differential is the result of the factors described in Toronto Hydro’s response to part (b) above.

### Table 1: OEB Approved Cost versus Current Cost Forecast

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>OEB Approved Cost ($M)</th>
<th>Current Forecast – 2018 ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station Cost</strong></td>
<td>Land</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Building</td>
<td>53.3</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>Substation Equipment</td>
<td>52.6</td>
<td>45.5</td>
</tr>
<tr>
<td></td>
<td>Distribution Modification</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Tunnel</strong></td>
<td>Design &amp; Construction PM – Substation</td>
<td>6.2</td>
<td>26.1</td>
</tr>
<tr>
<td></td>
<td>Design &amp; Construction PM</td>
<td>0.6</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>14</td>
<td>14.4</td>
</tr>
<tr>
<td><strong>Hydro One</strong></td>
<td>Capital Contribution</td>
<td>60.4</td>
<td>39.9</td>
</tr>
<tr>
<td><strong>Total Cost:</strong></td>
<td></td>
<td>195.0</td>
<td>204.0</td>
</tr>
</tbody>
</table>

d) For the purpose of rate base calculation as it applies to Copeland TS – Phase 2 “In-Service Attainments” (ISA), the following financial years were used:

- ISA of MV Switchgear (A5-6CX and A7-8CX, A9CX – Transfer Bus) in 2022;
- ISA of Power Transformers (T2, T4 and T5) in 2023; and
- ISA of remainder spending required for Phase 2 project closing in 2024.
e) At this time, there is no expectation of any significant variances in the 2019 forecast for Copeland TS – Phase 2 project as compared to what was filed. Accordingly, no updates are expected to be made to the 2019 rate base calculation.

f) Toronto Hydro does not have a cost breakdown between labour and materials for Copeland TS – Phase 2. However, cost breakdown is available based on type of work and asset type as illustrated in Figure 1 below:

![Figure 1: Copeland TS – Phase 2 Cost Breakdown](image-url)
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 96:

Reference(s): Exhibit 2B, Section E8.1, p. 12, pp. 17-18, p. 25

a) Please advise whether the dual control centre will have greater functionality than its existing primary control centre. If so, please provide the costs associated with the incremental functionality (Exhibit 2B / Section E8.1 / p. 12).

b) Please advise whether it is Toronto Hydro’s intent to eventually make the new dual control centre its primary control centre (Exhibit 2B / Section E8.1 / p. 12).

c) Please explain in more detail how a dual control centre protects against cyber threats (Exhibit 2B / Section E8.1 / p. 17).

d) Please confirm that the dual control centre is forecast to come into service in 2022 (Exhibit 2B / Section E8.1 / p. 18)

e) Please confirm that the $40.2 million budget for the dual control centre reflects the entire capital investment for the project (including all IT systems) (Exhibit 2B / Section E8.1 / p. 18).

f) Please provide the total annual impact that the dual control centre will have on OM&A costs (e.g. incremental Full Time Equivalents (FTEs), incremental maintenance, etc.) (Exhibit 2B / Section E8.1 / p. 18).

g) Please provide the total cost of Option 4 (Exhibit 2B / Section E8.1 / p. 25).
RESPONSE:

a) The proposed dual Control Centre will have the same functionality as the existing primary Control Centre, as outlined in section Exhibit 2B, E8.1.5.3 (Option 3.2 / p. 23-24). However, the creation of the dual Control Centre through the Control Operations Reinforcement Program will better position Toronto Hydro to address current and emerging technical and functional requirements.

b) No. Toronto Hydro’s intends to have both control centers operating in parallel.

c) As described in Exhibit 2B, Section E8.1 at pages 17-18,

d) Confirmed.

e) Confirmed.

f) The estimated increase in OM&A costs resulting from the dual Control Centre is approximately $350,000 per year. This is composed of a) $150,000 in facilities related OM&A costs, such as utilities and maintenance, and b) $200,000 in information technology related costs, such as maintenance and licenses. There will be no incremental increase in total Control Centre FTEs.

g) Toronto Hydro does not have a cost estimate for Option 4. However, Toronto Hydro expects that this option would not be much lower in cost than the preferred option.
This is because, as described in Exhibit 2B, Section E8.1 at page 26, a physical space reduction of around 50-60 percent would not result in a proportional reduction in costs. For example, it would not significantly reduce mechanical and electrical building expenditures, as described at page 19, nor would it alleviate building alteration and demolition costs which are also required in Option 4.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 97:

Reference(s): Exhibit 2B, Section E8.2, p. 8, p. 11, pp. 12-13, p. 19

a) Please explain how Toronto Hydro will ensure that the work completed in the facilities management and security program is efficiently coordinated with its other capital programs. Please provide specific examples of how the work will be coordinated.

b) Please provide the total 2020-2024 capital expenditure for renovating the trades training area at 500 Commissioners Work Centre (Exhibit 2B / Section E8.2 / p. 8).

c) Please provide the total 2020-2024 capital expenditure for superstructure and concrete repairs at 500 Commissioners Work Centre (Exhibit 2B / Section E8.2 / p. 8).

d) Please provide the total 2020-2024 capital expenditure for replacement of HVAC systems at 500 Commissioners and the associated OM&A cost reduction (resulting from lower electricity use) (Exhibit 2B / Section E8.2 / p. 11).

e) Please provide the 2020-2024 total capital expenditure for sump pump replacement at six stations (Exhibit 2B / Section E8.2 / pp. 12-13).

f) With respect to the security improvements-related capital expenditures, please provide the amount that is directly related to addressing cyber security threats (Exhibit 2B / Section E8.2 / p. 19).
RESPONSE:

a) Toronto Hydro will ensure efficient coordination of work between the Facilities Management and Security program and other capital programs through active communication with other departments as well as working closely with Toronto Hydro’s Program Management and Support team (see Exhibit 4A, Tab 2, Schedule 9), which plays a key role in the planning, budgeting, scheduling, resourcing, and tracking and reporting of Toronto Hydro’s distribution-related programs.

b) Toronto Hydro estimates that it will cost approximately $2 million over the 2020-2024 period to renovate the Trades area. This estimate is derived from past construction costs for interior projects of similar size and scope.

c) A structural condition assessment was performed at 500 Commissioners and significant superstructure and concrete deficiencies were identified. Based on experience and discussions with the third party assessor, Toronto Hydro estimates that it will cost approximately $2.5 million over the 2020-2024 period to perform these repairs.

d) Based on costs for past HVAC replacements, Toronto Hydro estimates that the replacement of HVAC systems is expected to cost approximately $650,000. Toronto Hydro is unable to quantify cost savings resulting from this replacement during the 2020-2024 period. However, based on experience with these types of replacements, Toronto Hydro is certain that this replacement will result in lower electricity consumption at 500 Commissioners.
e) Toronto Hydro estimates that sump pump replacements at six stations will cost approximately $125,000. This is an estimated cost based on previous experience with installing similar sump pumps at other stations.

f) The OEB’s Cyber Security Framework recommends a number of controls be in place to limit access to assets and associated facilities to authorized users only.\(^1\) As discussed in detail in Exhibit 2B, Section E8.2.3.2, to strengthen its security, Toronto Hydro plans on investing in physical security infrastructure. Therefore, the entire $14.6 million, as shown in Table 4, is directly related to addressing cyber security threats.

RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 98:

Reference(s): Exhibit 2B, Section E8.3, p. 8, p. 11

Preamble:
Toronto Hydro proposes to spend $42.5 million during the 2020-2024 period compared to the $19.1 million spent in the 2015-2019 period for the fleet and equipment services capital program. Toronto Hydro explains that this is due to requiring the replacement of a larger number of heavy duty vehicles, due to their age and condition (Exhibit 2B / Section E8.3 / pp. 8, 11).

a) Please explain why, if historical replacements of both light and heavy vehicles were paced appropriately, there is such a large increase in the capital expenditures for this program in the 2020-2024 period.

RESPONSE:

a) Toronto Hydro rejects the premise of this question as the utility has been pacing its investments appropriately in previous periods based on lifecycle analysis and condition assessment data available at the time. As mentioned in Exhibit 2B, Section E8.3, Toronto Hydro’s expenditures and asset replacement planning begins several years in advance, primarily due to the lead time required to procure vehicles. To identify candidates for future replacements, Toronto Hydro utilizes lifecycle analysis (LCA) and asset condition assessments collected during vehicle inspections. Although the LCA identifies the optimal age for vehicle replacements for the purposes of
expenditure planning, Toronto Hydro replaces vehicles according to the results of vehicle condition assessments.

The question implies that there is an increase in the number of vehicles requested in this rate period. However, the utility has proposed virtually the same number of vehicles for replacement as compared to the 2015-2019 period. The only difference is that in the 2015-2019 period, Toronto Hydro required funding for 62 heavy duty vehicles and 199 light duty vehicles. In the current 2020-2024 period, Toronto Hydro requires funding for 101 heavy duty and 159 light duty vehicles. As shown in Exhibit 2B, Section E8.3, Tables 6 and 7, heavy duty vehicles are five to ten times more expensive than light duty vehicles. Therefore, the increase is largely driven by the composition of the necessary vehicles as well as exchange rate fluctuations impacting these vehicles.
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 99:
Reference(s): Exhibit 2B, Section E8.4, p. 14, p. 16, p. 18, pp. 21-22

a) Please provide the amount of the total IT capital budget that is directly related to addressing cyber-security threats (Exhibit 2B / Section E8.4 / p. 14).

b) Please provide unit cost analysis comparing historical (2015-2019) to forecast (2020-2024) for the IT hardware categories listed in Table 6 (Exhibit 2B / Section E8.4 / p. 16).

c) Please provide variance analysis between planned and actual capital expenditures for the IT systems / software upgrades listed in Table 7 (Exhibit 2B / Section E8.4 / p. 18), Table 8 (Exhibit 2B / Section E8.4 / p. 21), Table 9 (Exhibit 2B / Section E8.4 / p. 21), Table 10 (Exhibit 2B / Section E8.4 / p. 22).

RESPONSE:

a) Toronto Hydro is unable to isolate how much of the IT capital budget is dedicated specifically to addressing cyber-security threats, as elements combatting cyber-security risks are closely embedded into various IT capital initiatives.

b) Error! Reference source not found. includes the unit cost analysis for the IT Hardware asset categories comparing historical figures (2015-2019) to forecast figures (2020-2024).
The unit cost for the virtual servers have decreased because of technological advancements making it possible to have a denser virtual server environment. In other words, more virtual servers can be hosted on the same volume of hardware.

The average unit cost of personal computing devices and mobile phones has increased slightly because Toronto Hydro anticipates the vendor pricing for these assets will increase in cost in the 2020-2024 period versus the 2015-2019 period. Similarly, Toronto Hydro anticipates that the vendor pricing for printers & plotters will decrease slightly in the 2020-2024 period.
c) Table 2 shows the variance between the planned and actual capital expenditures for Tier 1 IT Systems.

<table>
<thead>
<tr>
<th>IT Systems</th>
<th>2015-2019 (Actuals/Bridge) ($M)</th>
<th>2020-2024 Plan ($M)</th>
<th>Variance ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP</td>
<td>62.8</td>
<td>46.3</td>
<td>-16.5</td>
</tr>
<tr>
<td>CIS</td>
<td>10.0</td>
<td>38.5</td>
<td>28.5</td>
</tr>
<tr>
<td>Tier 1 Systems Excluding CIS &amp; ERP</td>
<td>36.7</td>
<td>40.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Tier 1 Systems Total</td>
<td>109.5</td>
<td>125.0</td>
<td>15.5</td>
</tr>
</tbody>
</table>

The reduction in capital expenditure in the ERP program is mainly due to the fact that the 2020-2024 expenditure plan focuses on upgrading the ERP system and integrating it with Toronto Hydro’s other existing core IT systems. These upgrades and integrations are expected to cost less than completely replacing Toronto Hydro’s legacy ERP system with a new system, as was the case during the 2015-2019 rate period. The CIS investments expected to cost more in the 2020-2024 period because Toronto Hydro plans to undertake a major upgrade to this system. There were no major upgrades planned and executed to the CIS system during the 2015-2019 period. The increase in capital expenditures for Tier 1 Systems (excluding CIS & ERP) is mainly due to inflation.

Table 3 shows the variance between the planned and actual capital expenditures for Tier 2 IT Systems. As discussed in Exhibit 2B, Section E8.4 at page 21, vendors are reducing the lifecycle of Toronto Hydro’s Tier 2 systems. As a result, Toronto Hydro expects that the number of upgrades required for Tier 2 Systems will increase in the 2020-2024 period.
Table 3: Variance Analysis of Tier 2 Applications Upgrades Costs ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2015-2019</th>
<th>2020-2024</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2 Systems</td>
<td>8.0</td>
<td>13.4</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Table 4 shows the variance between the planned 2020-2024 capital expenditures and the 2015-2019 capital expenditures for Software Enhancements. As discussed in Exhibit 2B, Section E8.4 at page 22, the increase in cost is driven by customer-related and operational enhancements which are necessary to mitigate any risks (such as reliability and cybersecurity) and to address customer service demands.

The number of software enhancements is expected to increase in the 2020-2024 period because with the implementation of the new foundational ERP system, some enhancements were deferred from the 2015-2019 period as the design and implementation of these enhancements depended on the core ERP system.

Table 4: Variance Analysis of Software Enhancements Costs ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2015-2019</th>
<th>2020-2024</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Enhancements</td>
<td>22.0</td>
<td>60.9</td>
<td>38.9</td>
</tr>
</tbody>
</table>

Table 5 shows the variance between the planned 2020-2024 capital expenditures and the 2015-2019 capital expenditures for Regulatory Compliance investments. Toronto Hydro anticipates there will be an increase in investment needs to complete new compliance-related public policy initiatives (e.g. cyber-security).

Table 5: Variance Analysis of Regulatory Compliance Costs ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2015-2019</th>
<th>2020-2024</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory Compliance</td>
<td>7.8</td>
<td>9.3</td>
<td>1.5</td>
</tr>
</tbody>
</table>
RESPONSES TO OEB STAFF INTERROGATORIES

INTERROGATORY 100:

Reference(s): Exhibit 2B, Section E8.4, Appendix A, p. 8, p. 13, p. 27, p. 30

a) Please explain the revenue and operational expense amounts presented for 2017 and 2020 used in the benchmarking analysis (Exhibit 2B / Section E8.4 / Appendix A / p. 8). If it includes the electricity commodity costs and revenues, please explain why those amounts would be included.

b) Please explain why Toronto Hydro’s 2017 and 2020 hardware costs are significantly higher than the peer group and its software costs are significantly lower than the peer group (Exhibit 2B / Section E8.4 / Appendix A / pp. 13, 27).

c) Please explain why Toronto Hydro’s 2020 IT budget is more capital intensive than the peer group (Exhibit 2B / Section E8.4 / Appendix A / p. 30).

RESPONSE (PREPARED BY GARTNER):

a) The 2017 revenue and operational expense amounts were provided to Gartner by Toronto Hydro. Electricity commodity costs and revenue are and should be included per Gartner definitions – this data is included for all our benchmark clients and provides an accurate comparison. In addition, Gartner benchmarks are based on an alignment of business and IT support for that business. Because IT spending and staffing represent support for the whole of the business, all revenue and operational expense should be included.
b) Gartner does not have enough information to explain this.

c) Gartner does not have enough information to explain this.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 17:
Reference(s): Exhibit 2B, Section A2, p. 5

Please define original serviceable life.

RESPONSE:
The capital investment category definitions in Table 2 at the reference provided for this interrogatory were adapted from the OEB’s definitions on page 7 of Chapter 5 of the OEB’s Filing Requirements for Electricity Distribution Rate Applications. The word “serviceable” is a typo; the correct word is “service”. Toronto Hydro’s considers “original service life” to be synonymous with “useful life.” Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-12 for more information on the useful life concept.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 18:

Reference(s): Exhibit 2B, Section C2, p. 20

a) Please define material deterioration condition.

b) Please define end of serviceable life condition.

RESPONSE:

a) The term “Material Deterioration” describes assets with Asset Condition Assessment (ACA) results that fall into the “HI4” Health Index Band. Assets in this band have high health scores, which represent measurable deterioration, with degradation processes starting to move from normal ageing to processes that potentially threaten failure. In this condition, probability of failure is elevated and rising as further degradation progresses. Toronto Hydro considers assets in HI4 for intervention.

b) The term “End of Serviceable life” describes assets with Asset Condition Assessment (ACA) results that fall into the HI5 band. Assets in this band have very high health scores, which represent unsatisfactory condition, where advanced degradation processes have reached the point that they actually threaten failure. In this condition, probability of failure is significantly raised, and the rate of further degradation will be relatively rapid. Assets in HI5 condition typically require intervention.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 19:
Reference(s): Exhibit 2B, Section A4, p. 10

Please define Assets Past Useful Life.

RESPONSE:
Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-12.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 20:

Reference(s): Exhibit 2B, Section A4, p. 10

THESL indicates the most significant driver of investment in Toronto Hydro’s DSP is asset failure and failure risk due to a continuing backlog of deteriorating and obsolete assets.

a) Please provide the asset classes that THESL has multi-year failure data for.

b) Does THESL track the age an asset fails for all asset classes?

RESPONSE:

a) Toronto Hydro captures this information for the following major asset classes:

- Overhead Transformers
- Overhead Switches
- Poles
- Cable Chambers
- Network Protector
- Underground Switches
- Underground Transformers
- Vaults
- Station Transformers
- Station Battery

Panel: Distribution System Capital and Maintenance
Panel: Distribution System Capital and Maintenance

1. Station Air Compressor
2. Station Switchgear
3. Station Circuit Breaker

b) The age an asset fails is not tracked for all asset classes. Toronto Hydro aims to capture this information when the failed asset is removed from service through the utility’s quality programs in Standards and Policies. Please refer to Exhibit 4A, Tab 2, Schedule 9.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 21:

Reference(s): Exhibit 2B, Section A4, p. 10, Figure 3

THESL indicates that as of the end of 2017, approximately 24 percent of assets will be in-service past their useful life, as shown in Figure 3 below.

![Pie chart showing percentages of assets past useful life]

**Figure 3: Percentage of Assets Past Useful Life**

a) Please provide the calculation that underpins the percentages in Figure 3.

b) Please provide a pie chart that shows the Percentage of Assets with Health Index Scores of H14 and H15 by 2018; Percentage of Assets with Health Index Scores of H14 and H15 at the end of Forecast Period (2025); and Percentage of Assets that do not have a Health Index Score of H14 or H15.

c) Please provide the calculation that underpins part b).
RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-12.

b) The following figure shows the percentage of assets in HI4 or HI5 condition as of the end of 2017 and the percentage of additional assets forecasted to be in HI4 or HI5 condition by 2025. Please note that this chart pertains only to the subset of asset classes for which Toronto Hydro calculates Health Scores (i.e. assets for which Toronto Hydro does not calculate health scores (e.g. cables; pole-top transformers) are excluded from the chart.

![Diagram](image)

Figure 1: Percentage of Assets with Health Index Scores of HI4 or HI5
c) The data used to produce Figure 1 in part (b) above is based on the Current Health Index distribution (as of the end of 2017) provided in Exhibit 2B, Section D, Appendix C, Table 2 and the Future Health Index distribution (by 2025), provided in Exhibit 2B, Section D, Appendix C, Table 3. The 9 percent value is the current proportion of assets in HI4 and HI5. The 16 percent value is the additional proportion projected to be in HI4 and HI5 by 2025.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 22:
Reference(s): Exhibit 2B, Section A6, p. 33, Table 7

a) Please provide the percentage of capital that is undertaken by external contractors for each of the years 2015 to 2018 and forecast for 2019 to 2024.

b) Please provide the percentage of planned capital budget compared to reactive capital budget for each of the years 2015 to 2018 and forecast for 2019 to 2024.

c) Please provide the percentage of planned capital work executed as planned for each of the years 2015 to 2018.

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 4A-AMPCO-93 (b).

b) Please see to Table 1 below which contains 2015-2017 actual and 2018-2024 forecasted percentages of planned capital and reactive capital, respectively, as compared to total capital as presented in Appendix 2-AA.

Planned Capital is based on total capital in Appendix 2-AA (labeled as ‘subtotal’), but excludes demand based projects related to Customer Connections and Externally Initiated Plant Relocations & Expansion, and excludes Reactive and Corrective Capital. The percentage of reactive capital included in the table below is based on the Reactive...
and Corrective Capital program as shown in Appendix 2-AA over total capital in Appendix 2-AA (labeled as ‘subtotal’). Note that 2018 actuals are not available at this time.

**Table 1: Percentage of Planned and Reactive Capital versus Total Capital Expenditures (2015-2024)**

<table>
<thead>
<tr>
<th></th>
<th>Historical</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned CapEx</td>
<td>84.5%</td>
<td>81.1%</td>
<td>83.9%</td>
</tr>
<tr>
<td>Reactive CapEx</td>
<td>8.5%</td>
<td>10.6%</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

**Table 2: Percentage of Planned and Reactive Capital versus Total Capital Expenditures (2015-2018) ($ Millions)**

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan</td>
<td>Actual</td>
<td>Plan</td>
<td>Actual</td>
</tr>
<tr>
<td>Planned Capital</td>
<td>455.9</td>
<td>415.5</td>
<td>426.5</td>
<td>414.7</td>
</tr>
<tr>
<td>Total Capital</td>
<td>531.1</td>
<td>491.4</td>
<td>518.8</td>
<td>511.6</td>
</tr>
<tr>
<td>% Planned CapEx executed as planned</td>
<td>91%</td>
<td>97%</td>
<td>116%</td>
<td>n/a</td>
</tr>
</tbody>
</table>

c) Please refer to Table 2 which includes the percentage of planned capital work executed as planned for each of the years from 2015 to 2018. Note that 2018 actuals are not available at this time. Also note that these results do not take into consideration demand-driven projects. Please see response to part (b) for the definition of projects considered Planned Capital.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 23:

Reference(s): Exhibit 2B, Section A6, pp. 33-41

a) Please list the programs where the pace of work is being maintained.

b) Please list the programs where the pace of work is being accelerated.

c) Please list the programs where the pace of work is being scaled back.

RESPONSE:

a) Based on the five-year average expenditures for each capital investment program between the 2015-2019 period and the 2020-2024 period, the pace of work is being maintained for the following:

- Customer Connections;
- Generation Protection, Monitoring and Control;
- Load Demand;
- Area Conversions;
- Network System Renewal;
- Reactive and Corrective Capital; and
- Underground System Renewal – Horseshoe.
b) Based on the five-year average expenditures for each capital investment program between the 2015-2019 period and the 2020-2024 period, the pace of work is being accelerated for the following:

- Externally Initiated Plant Relocations & Expansion;
- Metering;
- Stations Renewal;
- Underground System Renewal – Downtown*;
- Overhead System Renewal;
- Energy Storage Systems;
- Network Condition Monitoring and Control*;
- Facilities Management and Security;
- Fleet and Equipment;
- Information Technology and Operational Technology Systems; and
- Control Operations Reinforcement*.

*New programs or programs that are now standalone programs

c) Based on the five-year average expenditures for each capital investment program between the 2015-2019 period and the 2020-2024 period, the pace of work is being scaled back for the following:

- Stations Expansion; and
- System Enhancements.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 24:
Reference(s): Exhibit 2B, Section C2, p. 10

a) Please provide the number of box construction poles replaced for each of the years 2013 to 2018 and forecast to be replaced for each of the years 2019 to 2024.

b) Please provide the cost to replace box construction poles for each of the years 2013 to 2018 period and the forecast cost for the years 2019 to 2024.

c) Please calculate the improvements expected in the average outage restoration time for 22,700 downtown residential and small business customers.

RESPONSE:

a) Please see tables below:

Table 1: Number of Box Construction Poles Replaced (Actuals)

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>102</td>
<td>818</td>
<td>727</td>
<td>978</td>
<td>717</td>
</tr>
</tbody>
</table>

Table 2: Number of Box Construction Poles Replaced (Forecast)

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>2,900</td>
<td>3,800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b) Please see table below:

Table 3: Cost to Replace Box Construction Poles ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box Construction</td>
<td>13.8</td>
<td>20.1</td>
<td>19.6</td>
</tr>
</tbody>
</table>


c) The improvement to each customer’s restoration times will differ depending on their currently reliability experience; however, based on a 10-year historical trend, the average restoration time is expected to improve by approximately one half when converting from 4.16 kV Box Construction to 13.8 kV.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 25:

Reference(s): Exhibit 2B, Section C2, p. 11

a) Please provide the original number of network units in its downtown secondary distribution network that are not water tight.

b) Please provide the cost to replace 225 non-submersible protectors during the 2015-2019 period.

c) Please provide the forecast of the number of network units in its downtown secondary distribution network that are not water tight at the end of 2019 and 2024.

d) Please provide the cost to replace 240 non-submersible protectors during the 2020-2024 period.

RESPONSE:

a) Originally all network protectors in Toronto Hydro were not water tight. As of the end of 2015, there remained 770 protectors that were not water tight.

b) Normally network protectors and network transformers are replaced as a complete unit at an average cost of approximately $0.2 million. Therefore, the cost of replacing 225 units during the 2015-2019 period would be approximately $45 million
(unadjusted for inflation and engineering and support costs).

c) At the end of 2019 the forecast number of protectors that are not water tight is approximately 660. At the end of 2024, the forecast number of protectors that are not water tight is approximately 420.

d) Normally network protectors and network transformers are replaced as a complete unit at an average cost of approximately $0.2 million. Therefore, the cost of replacing 240 units during the 2020-2024 period would be approximately $48 million (unadjusted for inflation and engineering and support costs).
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 26:
Reference(s): Exhibit 2B, Section C2, p. 23

Please provide the cost per km of trimming and clearing vegetation located near overhead feeders for the years 2015 to 2018 and provide the calculation.

RESPONSE:
Please refer to Toronto Hydro’s response to interrogatory 1B-SEC-16.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 27:

Reference(s): Exhibit 2B, Section D1, p. 13

THESL indicates age and ACA are leading indicators of failure.

Please provide the asset classes where THESL has determined from the data that the majority of units at or past useful life have condition ratings of H14 or H15.

RESPONSE:
The asset classes where the majority of units at or past useful life have condition ratings of H14 or H15 are KSO oil circuit breakers and underground vaults.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 28:
Reference(s): Exhibit 2B, Section D2, p. 12, Table 1

a) Under the Condition Column, please provide the number of assets that correspond to Overhead (11%), Underground (3%), Network (5%), and Stations (8%) and Total (9%).

b) Please provide the Condition asset numbers and percentages at the end of 2024 for Overhead, Underground, Network, Stations and Total.

c) Under the Age Column, please provide the number of assets that correspond to Overhead (17%), Underground (25%), Network (24%), and Stations (37%) and Total (24%).

d) Please complete Table 1 Asset Management Performance Indicators by System Type based on the data that underpins the capital plan in EB-2014-0116.

RESPONSE:

a) Please see Table 1 below for the number of assets that correspond to Overhead (11%), Underground (3%), Network (5%), Stations (8%), and Total (9%).
Table 1: Asset count for HI4/Hi5

<table>
<thead>
<tr>
<th>System</th>
<th>Asset Count – HI4/Hi5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead</td>
<td>11,971</td>
</tr>
<tr>
<td>Underground</td>
<td>1,215</td>
</tr>
<tr>
<td>Network</td>
<td>207</td>
</tr>
<tr>
<td>Station</td>
<td>172</td>
</tr>
<tr>
<td>Total</td>
<td>13,565</td>
</tr>
</tbody>
</table>

b) Please see the table below for the projected counts and percentages of assets in HI4 or HI5 condition at the end of 2024 for Overhead, Underground, Network, Stations, and Total, without intervention.

Table 2: Asset count in HI4 or HI5 with percentage at the end of 2024

<table>
<thead>
<tr>
<th>System</th>
<th>Condition (Percentage of Assets in HI4 or HI5)</th>
<th>Condition (Count of Assets in HI4 or HI5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead</td>
<td>32%</td>
<td>34,407</td>
</tr>
<tr>
<td>Underground</td>
<td>7%</td>
<td>2,985</td>
</tr>
<tr>
<td>Network</td>
<td>23%</td>
<td>940</td>
</tr>
<tr>
<td>Station</td>
<td>44%</td>
<td>915</td>
</tr>
<tr>
<td>Total</td>
<td>25%</td>
<td>39,247</td>
</tr>
</tbody>
</table>

c) Please see the table below for the number of assets that correspond to Overhead (17%), Underground (25%), Network (20%), Stations (37%), and Total (24%).

---

1 Due to an administrative error, the percentage of Network assets past useful life was incorrectly stated as 24% in Exhibit 2B, Section D2, Table 1. The correct value is 20%.
Table 3: Asset Count for Assets Past Useful Life

<table>
<thead>
<tr>
<th>System</th>
<th>Non-Linear Assets (Units)</th>
<th>Linear Assets (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead</td>
<td>42,674</td>
<td>891</td>
</tr>
<tr>
<td>Underground</td>
<td>17,599</td>
<td>3,304</td>
</tr>
<tr>
<td>Network</td>
<td>875</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Stations</td>
<td>1,045</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Total</td>
<td>62,193</td>
<td>4,195</td>
</tr>
</tbody>
</table>

d) Please see Table 4 below for Asset Management Performance Indicators based on the data that underpinned the EB-2014-0116 application. The requested data is not available for a subset of indicators. Please see the explanations below.

- **Oil Deficiencies**: Starting in 2015, Toronto Hydro revised the way it tracked oil deficiencies. As such, 2013 data that underpinned the capital plan in EB-2014-0116 is not available in a comparable form with what is presented as of 2017 year end.

- **Condition**: Toronto Hydro updated its Asset Condition Assessment methodology in 2017 to establish new Health Index scores. As a result, comparable condition values are not available for the previous filing period.

- **Oil Containing PCBs**: Toronto Hydro is unable to provide this performance indicator as it was not tracked at the time EB-2014-0116 evidence was prepared.

- **Legacy Assets**:
  - **Rear Lot**: For the data that underpinned the EB-2014-0116, rear lot customer count was used to identify the remaining rear lot configurations in the system. As a result, kilometres is not available for that time period. For comparison the number of rear lot customers at the end of 2017 was approximately 6,600 customers.
Poles with Porcelain Insulators: Toronto Hydro began the porcelain insulator identification program in 2015 and, as a result, data prior to 2015 is unavailable.
## Table 4: Asset Management Performance Indicators by System Type Corresponding to EB-2014-0116 Application

| System     | Oil Deficiencies (Number of assets) | Priority Deficiencies (Number assigned) | Customer Hours of Interruption due to Defective Equipment
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead</td>
<td>Not Available</td>
<td>1,392 (20%)</td>
<td>140,806 (36%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>196,070 (43%)</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
</tr>
<tr>
<td>Underground</td>
<td>Not Available</td>
<td>3,775 (55%)</td>
<td>212,384 (55%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>237,415 (53%)</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
</tr>
<tr>
<td>Network</td>
<td>Not Available</td>
<td>451 (7%)</td>
<td>4 (0%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (0%)</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
</tr>
<tr>
<td>Stations</td>
<td>Not Available</td>
<td>1254 (18%)</td>
<td>33,841 (9%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17,446 (4%)</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
</tr>
<tr>
<td>Total</td>
<td>Not Available</td>
<td>6,872 (100%)</td>
<td>387,035 (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>450,932 (100%)</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
</tr>
</tbody>
</table>

### Notes:
- All figures use 2013 data, unless otherwise noted.
- This is based on the 5-year average of 2009-2013. Same assumption was made in EB-2018-0165 which used the average from 2013-2017.
- Paper Insulated Lead Covered (“PILC”) cable
- Asbestos Insulated Lead-Covered (“AILC”) cable
- Transformer Station (“TS”)
- Municipal Station (“MS”)
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 29:
Reference(s): Exhibit 2B, Section D2, p. 21

Please provide the cost impact of new and revised standards over the 2015 to 2019 period.

RESPONSE:
The cost impact of new and revised standards over the 2015 to 2018 period is provided in Table 1 below. The cost impact is determined for a subset of the new and revised standards that satisfy the following criteria:

1) where new equipment is added or existing is modified; and
2) the change is not due to equipment obsolescence or industry standard compliance; and
3) the cost impact is material.
Table 1: Cost impact of new and revised standards.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Revision Details</th>
<th>Driver</th>
<th>Equipment Additional Cost (per standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-3210 to 11-4650 (Revision #48)</td>
<td>Addition of Breakaway Links</td>
<td>Faster Restoration Time, Customer-Owned Service Mast Damage Prevention (Exhibit 2B Section D2)</td>
<td>$65</td>
</tr>
<tr>
<td>13-7010 (Revision #49)</td>
<td>1-Phase Submersible Transformer Design Improvements (includes change from Mild Steel to Stainless Steel Construction)</td>
<td>Reliability (Exhibit 2B Section D2)</td>
<td>$1,000 to $3,500 Additional Cost (Size Dependent)</td>
</tr>
</tbody>
</table>

The list of standards revised/created is detailed in the Appendix of the Standards Review 2018 Update (PSE) study, which can be found at Appendix B to Exhibit 2B, Section D. For 2015 to March 2018, Revision #44 to #53 are applicable. From March 2018 to December 2018, two additional revisions have been released but the associated changes do not satisfy the criteria above, and therefore are not included in Table 1.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 30:
Reference(s): Exhibit 2B, Section D1, p. 25

Please provide a copy of ISO55000, the International Standard for Asset Management.

RESPONSE:
Please see Appendices A, B, and C for a copy of the 2014 edition of the ISO 55000 Standard for Asset Management. The three documents are:

- Appendix A: ISO 55000: Asset Management – Overview, principles and terminology
- Appendix B: ISO 55001: Asset Management – Management systems – Requirements
- Appendix C: ISO 55002: Asset Management – Management systems – Guidelines for the application of ISO 550001
Asset management — Overview, principles and terminology

Gestion d’actifs — Aperçu général, principes et terminologie
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>iv</td>
</tr>
<tr>
<td>Introduction</td>
<td>v</td>
</tr>
<tr>
<td>1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>2 Asset management</td>
<td>1</td>
</tr>
<tr>
<td>2.1 General</td>
<td>1</td>
</tr>
<tr>
<td>2.2 Benefits of asset management</td>
<td>1</td>
</tr>
<tr>
<td>2.3 Assets</td>
<td>2</td>
</tr>
<tr>
<td>2.4 Overview of asset management</td>
<td>2</td>
</tr>
<tr>
<td>2.5 Overview of the asset management system</td>
<td>4</td>
</tr>
<tr>
<td>2.6 Integrated management systems approach</td>
<td>9</td>
</tr>
<tr>
<td>3 Terms and definitions</td>
<td>10</td>
</tr>
<tr>
<td>3.1 General terms</td>
<td>10</td>
</tr>
<tr>
<td>3.2 Terms relating to assets</td>
<td>13</td>
</tr>
<tr>
<td>3.3 Terms relating to asset management</td>
<td>14</td>
</tr>
<tr>
<td>3.4 Terms relating to asset management system</td>
<td>15</td>
</tr>
<tr>
<td>Annex A (informative) Information on asset management activities</td>
<td>16</td>
</tr>
<tr>
<td>Annex B (informative) Relationship between key elements of an asset management system</td>
<td>17</td>
</tr>
<tr>
<td>Bibliography</td>
<td>18</td>
</tr>
</tbody>
</table>
Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO’s adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Project Committee ISO/PC 251, Asset management.
Introduction

0.1 Purpose

This International Standard provides an overview of asset management and asset management systems (i.e. management systems for the management of assets). It also provides the context for ISO 55001 and ISO 55002.

International cooperation in the preparation of these standards has identified common practices that can be applied to the broadest range of assets, in the broadest range of organizations, across the broadest range of cultures.

0.2 Relationship with other standards

ISO 55001, ISO 55002 and this International Standard relate to a management system for asset management, which is referred to as an "asset management system" throughout the three standards.

ISO 55001, ISO 55002 and this International Standard can be used in combination with any relevant sector or asset type-specific asset management standards and technical specifications. ISO 55001 specifies requirements for an asset management system, while the other standards detail sector-specific, asset-specific or activity-specific technical requirements or give guidance on how ISO 55001 should be interpreted and applied within a specific sector or to particular asset types.

0.3 Target audience

This International Standard is primarily intended for use by:

— those considering how to improve the realization of value for their organization from their asset base
— those involved in the establishment, implementation, maintenance and improvement of an asset management system
— those involved in the planning, design, implementation and review of asset management activities; along with service providers.

0.4 Benefits of the standards

The adoption of ISO 55001, ISO 55002 and this International Standard enables an organization to achieve its objectives through the effective and efficient management of its assets. The application of an asset management system provides assurance that those objectives can be achieved consistently and sustainably over time.

Annex A provides additional information on areas related to asset management activities.

Annex B shows the relationship between key elements of an asset management system.
Asset management — Overview, principles and terminology

1 Scope

This International Standard provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management.

This International Standard can be applied to all types of assets and by all types and sizes of organizations.

NOTE 1 This International Standard is intended to be used for managing physical assets in particular, but it can also be applied to other asset types.

NOTE 2 This International Standard does not provide financial, accounting or technical guidance for managing specific asset types.

NOTE 3 For the purposes of ISO 55001, ISO 55002 and this International Standard, the term “asset management system” is used to refer to a management system for asset management.

2 Asset management

2.1 General

The factors which influence the type of assets that an organization requires to achieve its objectives, and how the assets are managed, include the following:

— the nature and purpose of the organization;
— its operating context;
— its financial constraints and regulatory requirements;
— the needs and expectations of the organization and its stakeholders.

These influencing factors need to be considered when establishing, implementing, maintaining and continually improving asset management.

Effective control and governance of assets by organizations is essential to realize value through managing risk and opportunity, in order to achieve the desired balance of cost, risk and performance. The regulatory and legislative environment in which organizations operate is increasingly challenging and the inherent risks that many assets present are constantly evolving.

The fundamentals of asset management and the supporting asset management system introduced in this International Standard, when integrated into the broader governance and risk framework of an organization, can contribute tangible benefits and leverage opportunities.

Asset management translates the organization’s objectives into asset-related decisions, plans and activities, using a risk based approach.

2.2 Benefits of asset management

Asset management enables an organization to realize value from assets in the achievement of its organizational objectives (see 2.5.3.4). What constitutes value will depend on these objectives, the nature and purpose of the organization and the needs and expectations of its stakeholders. Asset management
supports the realization of value while balancing financial, environmental and social costs, risk, quality of service and performance related to assets.

The benefits of asset management can include, but are not limited to the following:

a) **improved financial performance**: improving the return on investments and reducing costs can be achieved, while preserving asset value and without sacrificing the short or long-term realization of organizational objectives;

b) **informed asset investment decisions**: enabling the organization to improve its decision making and effectively balance costs, risks, opportunities and performance;

c) **managed risk**: reducing financial losses, improving health and safety, good will and reputation, minimizing environmental and social impact, can result in reduced liabilities such as insurance premiums, fines and penalties;

d) **improved services and outputs**: assuring the performance of assets can lead to improved services or products that consistently meet or exceed the expectations of customers and stakeholders;

e) **demonstrated social responsibility**: improving the organization’s ability to, for example, reduce emissions, conserve resources and adapt to climate change, enables it to demonstrate socially responsible and ethical business practices and stewardship;

f) **demonstrated compliance**: transparently conforming with legal, statutory and regulatory requirements, as well as adhering to asset management standards, policies and processes, can enable demonstration of compliance;

g) **enhanced reputation**: through improved customer satisfaction, stakeholder awareness and confidence;

h) **improved organizational sustainability**: effectively managing short and long-term effects, expenditures and performance, can improve the sustainability of operations and the organization;

i) **improved efficiency and effectiveness**: reviewing and improving processes, procedures and asset performance can improve efficiency and effectiveness, and the achievement of organizational objectives.

**2.3 Assets**

An asset is an item, thing or entity that has potential or actual value to an organization. The value will vary between different organizations and their stakeholders, and can be tangible or intangible, financial or non-financial.

The period from the creation of an asset to the end of its life is the asset life (see 3.2.2). An asset’s life does not necessarily coincide with the period over which any one organization holds responsibility for it; instead, an asset can provide potential or actual value to one or more organizations over its asset life, and the value of the asset to an organization can change over its asset life.

An organization may choose to manage its assets as a group, rather than individually, according to its needs, and to achieve additional benefits. Such groupings of assets may be by asset types, asset systems, or asset portfolios.

**2.4 Overview of asset management**

**2.4.1 General**

An organization’s top management, employees and stakeholders should implement planning, control activities (e.g. policies, processes or monitoring actions) and monitoring activities, to exploit opportunities and to reduce risks to an acceptable level.
Asset management involves the balancing of costs, opportunities and risks against the desired performance of assets, to achieve the organizational objectives. The balancing might need to be considered over different timeframes.

Asset management enables an organization to examine the need for, and performance of, assets and asset systems at different levels. Additionally, it enables the application of analytical approaches towards managing an asset over the different stages of its life cycle (which can start with the conception of the need for the asset, through to its disposal, and includes the managing of any potential post disposal liabilities).

2.4.2 Fundamentals

Asset management is based on a set of fundamentals.

a) **Value:** Assets exist to provide value to the organization and its stakeholders.

Asset management does not focus on the asset itself, but on the value that the asset can provide to the organization. The value (which can be tangible or intangible, financial or non-financial) will be determined by the organization and its stakeholders, in accordance with the organizational objectives.

This includes:

1) a clear statement of how the asset management objectives align with the organizational objectives;

2) the use of a life cycle management approach to realize value from assets;

3) the establishment of decision-making processes that reflect stakeholder need and define value.

b) **Alignment:** Asset management translates the organizational objectives into technical and financial decisions, plans and activities.

Asset management decisions (technical, financial and operational) collectively enable the achievement of the organizational objectives.

This includes:

1) the implementation of risk-based, information-driven, planning and decision-making processes and activities that transform organizational objectives into asset management plans (see 2.5.3.4);

2) the integration of the asset management processes with the functional management processes of the organization, such as finance, human resources, information systems, logistics and operations;

3) the specification, design and implementation of a supporting asset management system.

c) **Leadership:** Leadership and workplace culture are determinants of realization of value.

Leadership and commitment from all managerial levels is essential for successfully establishing, operating and improving asset management within the organization.

This includes:

1) clearly defined roles, responsibilities and authorities;

2) ensuring that employees are aware, competent, and empowered;

3) consultation with employees and stakeholders regarding asset management.

d) **Assurance:** Asset management gives assurance that assets will fulfil their required purpose.
The need for assurance arises from the need to effectively govern an organization. Assurance applies to assets, asset management and the asset management system.

This includes:

1) developing and implementing processes that connect the required purposes and performance of the assets to the organizational objectives;
2) implementing processes for assurance of capability across all life cycle stages;
3) implementing processes for monitoring and continual improvement;
4) providing the necessary resources and competent personnel for demonstration of assurance, by undertaking asset management activities and operating the asset management system.

2.4.3 The relationship of the asset management system to asset management

An asset management system is used by the organization to direct, coordinate and control asset management activities. It can provide improved risk control and gives assurance that the asset management objectives will be achieved on a consistent basis. However, not all asset management activities can be formalized through an asset management system. For example, aspects such as leadership, culture, motivation, behaviour, which can have a significant influence on the achievement of asset management objectives, may be managed by the organization using arrangements outside the asset management system. The relationship between key asset management terms is shown in Figure 1.

![Figure 1 — Relationships between key terms](image)

2.5 Overview of the asset management system

2.5.1 General

An asset management system is a set of interrelated and interacting elements of an organization, whose function is to establish the asset management policy and asset management objectives, and the processes, needed to achieve those objectives (see 3.4.3). In this context, the elements of the asset management
system should be viewed as a set of tools, including policies, plans, business processes and information systems, which are integrated to give assurance that the asset management activities will be delivered.

Asset management requires accurate asset information, but an asset management system is more than a management information system. Asset management interacts with many functions of an organization. The assets themselves can also support more than one function and more than one functional unit within the organization. The asset management system provides a means for coordinating contributions from and interaction between these functional units within an organization.

The asset management plan can enable an organization to create a link, if needed, between its asset management system (such as described by ISO 55001, ISO 55002 and this International Standard) and a variety of specific, technical asset management requirements. These specific, technical requirements are given in standards both inside and outside the ISO environment, and at the international, regional or national standardization levels; such standards provide information on strategies and tactics, as well as specific design, construction, material or process requirements. The definitions given in 3.4 refer specifically to the asset management system described in this International Standard; some of these terms may be defined differently for a specific, technical standard.

The establishment of an asset management system is an important strategic decision for an organization. ISO 55001 specifies the requirements of an asset management system, but does not specify the design of the system. ISO 55002 provides guidance on the design and operation of an asset management system.

### 2.5.2 Benefits of an asset management system

An asset management system provides a structured approach for the development, coordination and control of activities undertaken on assets by the organization over different life cycle stages, and for aligning these activities with its organizational objectives.

#### a) Creating an asset management system provides benefits in itself.

The process of implementing an asset management system can require significant time effort and expense; however, the organization does not need to wait until the entire system is fully operational to begin accruing benefits. The benefits, or quick wins, in areas such as risk reduction, opportunity identification or process improvement can be identified early in the implementation, and can be exploited to demonstrate returns and gain stronger stakeholder support.

- Asset management is data intensive and new tools and processes are often necessary to collect, assemble, manage, analyse and use asset data. The creation and use of these tools can stimulate and improve organizational knowledge and decision making.
- The process of creating an asset management system brings new perspectives to the organization and new ideas on value creation from the use of assets. These new perspectives can also stimulate improvements in other organizational functions, such as purchasing, finance, human resources and information technology.
- The creation of an asset management system is usually cross-functional and based on life cycle considerations; this can provide a focal point for addressing the issues of functional integration of the organization and life cycle planning.

#### b) Top management benefits from new insights and cross functional integration.

An asset management system can help in gaining an understanding of assets, their performance, the risks associated with managing assets, investment needs, and asset value as an input to decision making and organizational strategic planning.

- Top management should recognize the need to improve communication and interaction across functions. An asset management system inherently supports this interaction. It ensures that assets are managed in an integrated manner, and asset value is improved.
- An asset management system supports a long-term and sustainable approach to decision making.
— An asset management system provides an ideal framework for the identification, understanding and integration of the many technical standards, codes, guidelines and best practices that affect the organization's assets, and support the implementation of asset management.

— An asset management system supports energy management, environmental management and other activities related to sustainability.

c) Financial functions benefit from improved data and linkages.

Integration of an organization's strategic asset management plan (SAMP) (see 2.5.3.4 and 3.3.2), with its long-term financial plans can enable the balancing of short-term financial needs with the needs of medium-term activity plans, and with the much longer-term plans that some assets require.

— Robust financial information, based on integrated processes between the asset management and finance functions, is an important benefit of the asset management system. The linkage of asset management information to financial information is an important contribution of the asset management system to the financial function. This interaction supports improved assessment of the financial position and funding requirements of the organization in relation to its assets.

— The organization's risk-based decision making processes can become more effective by addressing asset and financial risks together, and by balancing performance, costs and risks.

— An effective taxonomy, which may be a feature of the asset management system, can enable an integrated financial and technical view of assets and asset systems.

d) Many parts of the organization benefit from an asset management system.

An asset management system touches many parts of the organization:

— the organization's human resources function may work with its asset management system on the development of competency models, training programs and processes for coaching and mentoring; these developments benefit both functions;

— some asset data comes from control systems, which are often isolated from other information systems. Integration of this data through the asset management system can provide new asset information, leading to improved organizational decision making;

— communicating with employees, suppliers and contracted service providers about the asset management system can result in improvements in the quality of asset information; it will also increase awareness amongst individuals, inside and outside of the organization, of their role in asset management decision making and the value of the activities they are undertaking;

— the asset management system can stimulate creativity and innovation by supporting people who understand the importance of asset management and are motivated to work towards achieving the asset management objectives.

2.5.3 Elements of an asset management system

2.5.3.1 General

An asset management system impacts the whole organization, including its stakeholders and external service providers, and can use, link or integrate many of the organization's activities and functions that would otherwise be managed or operated in isolation. The process of establishing an asset management system requires a thorough understanding of each of its elements and the policies, plans and procedures that integrate them.

The asset management system requirements described in ISO 55001 are grouped in a way that is consistent with the fundamentals of asset management:

— context of the organization (ISO 55001:2014, Clause 4);
2.5.3.2 Context of the organization

When establishing or reviewing its asset management system, an organization should take into account its internal and external contexts. The external context includes the social, cultural, economic and physical environments, as well as regulatory, financial and other constraints. The internal context includes organizational culture and environment, as well as the mission, vision and values of the organization. Stakeholder inputs, concerns and expectations are also part of the context of the organization. The influences of stakeholders are key to setting rules for consistent decision making and also contribute to the setting of organizational objectives, which in turn, influence the design and scope of its asset management system.

2.5.3.3 Leadership

Top management is responsible for developing the asset management policy and asset management objectives and for aligning them with the organizational objectives. Leaders at all levels are involved in the planning, implementation and operation of the asset management system. Top management should create the vision and values that guide policy, practice and actively promote these values inside and outside the organization. Top management also defines the responsibilities, accountabilities and asset management objectives and strategies, which create the environment for the asset management system. Leaders should lend their authority to supporting the asset management system, and should ensure its alignment to other management systems within the organization through appropriate organizational design.

Top management and leaders at all levels are responsible for ensuring that appropriate resources are in place to support the asset management system. These resources include appropriate funding, adequate and competent human resources, and information technology support.

Leaders should recognize and resolve conflicts between the internal culture of the organization and the performance of its asset management system.

Top management and leaders at all levels are responsible for communicating the organization's asset management objectives and the importance of its asset management system to all employees, customers, suppliers, contractors and other stakeholders. Communication should be two-way, with leaders being open to receiving information aimed at improving the asset management system from all levels.

2.5.3.4 Planning

The organizational objectives provide the overarching context and direction to the organization's activities, including its asset management activities. The organizational objectives are generally produced from the organization's strategic level planning activities and are documented in an organizational plan (see 3.1.15).

NOTE 1 The organizational plan can be referred to by other names, e.g. the corporate plan.
The principles by which the organization intends applying asset management to achieve its organizational objectives should be set out in an asset management policy (see 3.1.18). The approach to implementing these principles should be documented in a strategic asset management plan (SAMP) (see 3.3.2).

NOTE 2 A strategic asset management plan can be referred to by other names, e.g. an asset management strategy.

An organization's SAMP should be used to guide the setting of its asset management objectives, and to describe the role of the asset management system in meeting these objectives. This includes the structures, roles and responsibilities necessary to establish the asset management system and to operate it effectively. Stakeholder support, risk management and continuous improvement are important issues to be addressed in the establishment and operation of the asset management system. The SAMP can have a timeframe that extends beyond the organization's own business planning timeframe, requiring the asset management system to address the complete lifetimes of the assets.

The organization should also use its SAMP to guide its asset management system in the development of its asset management plans (i.e. in establishing what to do). The asset management plans themselves should define the activities to be undertaken on assets, and should have specific and measurable objectives (e.g. timeframes and the resources to be used). These objectives can provide the opportunity for alignment of operating plans with the organizational plan and any unit level business plans.

Aligning the asset management objectives with the organizational objectives, as well as linking asset reports to financial reports, can improve the organization's effectiveness and efficiency. The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization.

2.5.3.5 Support

The asset management system will require collaboration among many parts of the organization. This collaboration often involves the sharing of resources. Coordinating these resources and applying, verifying and improving their use should be objectives of the asset management system. It should also promote awareness of the asset management objectives across the whole organization.

The asset management system provides information to support the development of asset management plans and the evaluation of their effectiveness. Asset information systems can be extremely large and complex in some organizations, and there are many issues involved in collecting, verifying and consolidating asset data in order to transform it into asset information. Creating, controlling, and documenting this information is a critical function of the asset management system.

The asset management system should specify the competency requirements for personnel involved in asset management. The implementation, maintenance, evaluation and improvement of these competencies normally requires close cooperation with the organization's human resource management system. These two systems should be mutually supportive.

2.5.3.6 Operation

The organization's asset management system can enable the directing, implementation and control of its asset management activities, including those that have been outsourced. Functional policies, technical standards, plans and processes for the implementation of the asset management plans should be fed back into the design and operation of the asset management system.

Operation of the asset management system can sometimes require planned changes to asset management processes or procedures, which can introduce new risks. Risk assessment and control in the context of managing change is an important consideration in operating an asset management system.

When an organization outsources some of its asset management activities, this should not remove those outsourced activities from the control of the organization's asset management system. In situations where interacting activities are outsourced to different service providers, the responsibilities and complexity of control will be increased.
2.5.3.7 Performance evaluation

The organization should evaluate the performance of its assets, its asset management and its asset management system. Performance measures can be direct or indirect, financial or non-financial.

Asset performance evaluation is often indirect and complex. Effective asset data management and the transformation of data to information (see 2.5.3.5) is a key to measuring asset performance. Monitoring, analysis and evaluation of this information should be a continuous process. Asset performance evaluations should be conducted on assets managed directly by the organization and on assets which are outsourced.

Asset management performance should be evaluated against whether the asset management objectives have been achieved, and if not, why not. Where applicable, any opportunities that arose from having exceeded the asset management objectives should also be examined, as well as any failure to realize them. The adequacy of the decision-making processes should be examined carefully.

The performance of the asset management system should be evaluated against any objectives set specifically for the system itself (either when it was established, or following previous evaluations). The primary purpose of evaluating the system should be to determine whether it is effective and efficient in supporting the organization's asset management. Periodic audits should be used to evaluate the performance of the asset management system; these may be complemented by self-assessments.

The results of performance evaluations should be used as inputs into management reviews.

2.5.3.8 Improvement

An organization's asset management system is likely to be complex and continually evolving to match its context, organizational objectives and its changing asset portfolio. Continual improvement is a concept that is applicable to the assets, the asset management activities and the asset management system, including those activities or processes which are outsourced.

Opportunities for improvement can be determined directly through monitoring the performance of the asset management system, and through monitoring asset performance.

Nonconformities or potential nonconformities of the asset management system can also be identified through management reviews and internal or external audits. The nonconformities require corrective action and the potential nonconformities require preventive action.

Of particular importance are asset-related incidents or emergency situations, for which emergency response planning and business continuity planning for identified risks should be addressed by the asset management system. All such incidents, including unanticipated events, should be investigated and reviewed to see if any improvements are needed to the asset management system, to prevent their recurrence and to mitigate their effects.

Improvements should be risk assessed prior to being implemented.

2.6 Integrated management systems approach

Using an integrated management systems approach allows an organization's asset management system to be built on elements of its other management systems, such as for quality, environment, health and safety, and risk management. Building on existing systems can reduce the effort and expense involved in creating and maintaining an asset management system. It can also improve integration across different disciplines and improve cross-functional coordination.

Organizations that have implemented an integrated systems approach have demonstrated the benefits of the integrated approach and shortened the time to implementation of each new system. The integrated approach, in addition to reducing cost, reduces risks and improves acceptance of each new system.

Asset management, because it touches so many parts of the organization, is a natural candidate for an integrated systems approach.
3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General terms

3.1.1 audit
systematic, independent and documented process (3.1.19) for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled

Note 1 to entry: An audit can be an internal audit (first party) or an external audit (second party or third party), and it can be a combined or integrated audit (combining two or more disciplines).

Note 2 to entry: “Audit evidence” and “audit criteria” are defined in ISO 19011.

3.1.2 capability
<asset management> measure of capacity and the ability of an entity (system, person or organization (3.1.13)) to achieve its objectives (3.1.12)

Note 1 to entry: Asset management (3.3.1) capabilities include processes (3.1.19), resources, competences (3.1.3) and technologies to enable the effective and efficient development and delivery of asset management plans (3.3.2) and asset life (3.2.2) activities, and their continual improvement (3.1.5).

3.1.3 competence
ability to apply knowledge and skills to achieve intended results

3.1.4 conformity
fulfilment of a requirement (3.1.20)

3.1.5 continual improvement
recurring activity to enhance performance (3.1.17)

3.1.6 documented information
information required to be controlled and maintained by an organization (3.1.13) and the medium on which it is contained

Note 1 to entry: Documented information can be in any format and media and from any source.

Note 2 to entry: Documented information can refer to:

— the management system (3.4.2), including related processes (3.1.19);
— information created in order for the organization to operate (documentation);
— evidence of results achieved (e.g. records, key performance indicators).

3.1.7 effectiveness
extent to which planned activities are realized and planned results achieved

3.1.8 incident
unplanned event or occurrence resulting in damage or other loss
3.1.9 monitoring
determining the status of a system, a process (3.1.19) or an activity

Note 1 to entry: To determine the status, there may be a need to check, supervise or critically observe.

Note 2 to entry: For the purposes of asset management, monitoring may also refer to determining the status of an asset. This is typically referred to as "condition monitoring" or "performance monitoring".

3.1.10 measurement
process (3.1.19) to determine a value

3.1.11 nonconformity
non-fulfilment of a requirement (3.1.20)

Note 1 to entry: Nonconformity can be any deviation from asset management system (3.4.2) requirements, or from relevant work standards, practices, procedures, legal requirements, etc.

3.1.12 objective
result to be achieved

Note 1 to entry: An objective can be strategic, tactical or operational.

Note 2 to entry: Objectives can relate to different disciplines (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process (3.1.19)).

Note 3 to entry: An objective can be expressed in other ways, e.g. as an intended outcome, a purpose, an operational criterion, an asset management (3.3.1) objective or by the use of other words with similar meaning (e.g. aim, goal, or target).

Note 4 to entry: In the context of asset management systems (3.4.3), asset management objectives are set by the organization (3.1.13), consistent with the organizational objectives (3.1.14) and asset management policy (3.1.18), to achieve specific measurable results.

3.1.13 organization
person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives (3.1.12)

Note 1 to entry: The concept of organization includes, but is not limited to, sole-trader, company, corporation, firm, enterprise, authority, partnership, charity or institution, or part or combination thereof, whether incorporated or not, public or private.

3.1.14 organizational objective
overarching objective (3.1.12) that sets the context and direction for an organization's (3.1.13) activities

Note 1 to entry: Organizational objectives are established through the strategic level planning activities of the organization.

3.1.15 organizational plan
documented information (3.1.6) that specifies the programmes to achieve the organizational objectives (3.1.14)
3.1.16
outsource (verb)
make an arrangement where an external organization (3.1.13) performs part of an organization's function or process (3.1.19)

Note 1 to entry: An external organization is outside the scope of the management system (3.4.2), although the outsourced function or process is within the scope if its activities influence the effectiveness of the asset management system (3.4.3).

3.1.17
performance
measureable result

Note 1 to entry: Performance can relate either to quantitative or qualitative findings.

Note 2 to entry: Performance can relate to the management of activities, processes (3.1.19), products (including services), systems or organizations (3.1.13).

Note 3 to entry: For the purposes of asset management (3.3.1), performance can relate to assets (3.2.1) in their ability to fulfil requirements (3.1.20) or objectives (3.1.12).

3.1.18
policy
intentions and direction of an organization (3.1.13) as formally expressed by its top management (3.1.23)

3.1.19
process
set of interrelated or interacting activities which transforms inputs into outputs

3.1.20
requirement
need or expectation that is stated, generally implied or obligatory

Note 1 to entry: “Generally implied” means that it is custom or common practice for the organization (3.1.13) and stakeholders (3.1.22) that the need or expectation under consideration is implied.

Note 2 to entry: A specified requirement is one that is stated, for example in documented information (3.1.6).

3.1.21
risk
effect of uncertainty on objectives (3.1.12)

Note 1 to entry: An effect is a deviation from the expected — positive and/or negative.

Note 2 to entry: Objectives can relate to different disciplines (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process (3.1.19)).

Note 3 to entry: Risk is often characterized by reference to potential “events” (as defined in ISO Guide 73:2009, 3.5.1.3) and “consequences” (as defined in ISO Guide 73:2009, 3.6.1.3), or a combination of these.

Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated “likelihood” (ISO Guide 73:2009, 3.6.1.1) of occurrence.

Note 5 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.


3.1.22
stakeholder
person or organization (3.1.13) that can affect, be affected by, or perceive themselves to be affected by a decision or activity

Note 1 to entry: A “stakeholder” can also be referred to as an “interested party”. 
3.1.23

top management

person or group of people who directs and controls an organization (3.1.13) at the highest level

Note 1 to entry: Top management has the power to delegate authority and provide resources within the organization.

Note 2 to entry: If the scope of the management system (3.4.2) covers only part of an organization, then top management refers to those who direct and control that part of the organization. If multiple asset management systems (3.4.3) are employed, the systems should be designed to coordinate efforts.

3.2

Terms relating to assets

3.2.1

asset

item, thing or entity that has potential or actual value to an organization (3.1.13)

Note 1 to entry: Value can be tangible or intangible, financial or non-financial, and includes consideration of risks (3.1.21) and liabilities. It can be positive or negative at different stages of the asset life (3.2.2).

Note 2 to entry: Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, use rights, licences, intellectual property rights, reputation or agreements.

Note 3 to entry: A grouping of assets referred to as an asset system (3.2.6) could also be considered as an asset.

3.2.2

asset life

period from asset (3.2.1) creation to asset end-of-life

3.2.3

life cycle

stages involved in the management of an asset (3.2.1)

Note 1 to entry: The naming and number of the stages and the activities under each stage usually vary in different industry sectors and are determined by the organization (3.1.13).

3.2.5

asset portfolio

assets (3.2.1) that are within the scope of the asset management system (3.4.3)

Note 1 to entry: A portfolio is typically established and assigned for managerial control purposes. Portfolios for physical hardware might be defined by category (e.g. plant, equipment, tools, land). Software portfolios might be defined by software publisher, or by platform (e.g. PC, server, mainframe).

Note 2 to entry: An asset management system can encompass multiple asset portfolios. Where multiple asset portfolios and asset management systems are employed, asset management (3.3.1) activities should be coordinated between the portfolios and systems.

3.2.6

asset system

set of assets (3.2.1) that interact or are interrelated

3.2.7

asset type

grouping of assets (3.2.1) having common characteristics that distinguish those assets as a group or class

EXAMPLE Physical assets, information assets, intangible assets, critical assets (3.2.8), enabling assets, linear assets, information and communications technology (ICT) assets, infrastructure assets, moveable assets.
3.2.8 critical asset

asset (3.2.1) having potential to significantly impact on the achievement of the organization's (3.1.13) objectives (3.1.12).

Note 1 to entry: Assets can be safety-critical, environment-critical or performance-critical (3.1.17) and can relate to legal, regulatory or statutory requirements (3.1.20).

Note 2 to entry: Critical assets can refer to those assets necessary to provide services to critical customers.

Note 3 to entry: Asset systems (3.2.6) can be distinguished as being critical in a similar manner to individual assets.

3.3 Terms relating to asset management

3.3.1 asset management
coordinated activity of an organization (3.1.13) to realize value from assets (3.2.1)

Note 1 to entry: Realization of value will normally involve a balancing of costs, risks (3.1.21), opportunities and performance (3.1.17) benefits.

Note 2 to entry: Activity can also refer to the application of the elements of the asset management system (3.4.3).

Note 3 to entry: The term “activity” has a broad meaning and can include, for example, the approach, the planning, the plans and their implementation.

3.3.2 strategic asset management plan

SAMP
documented information (3.1.6) that specifies how organizational objectives (3.1.14) are to be converted into asset management (3.3.1) objectives (3.1.12), the approach for developing asset management plans (3.3.3), and the role of the asset management system (3.4.3) in supporting achievement of the asset management objectives.

Note 1 to entry: A strategic asset management plan is derived from the organizational plan (3.1.15).

Note 2 to entry: A strategic asset management plan may be contained in, or may be a subsidiary plan of, the organizational plan.

3.3.3 asset management plan
documented information (3.1.6) that specifies the activities, resources and timescales required for an individual asset (3.2.1), or a grouping of assets, to achieve the organization's (3.1.13) asset management (3.3.1) objectives (3.1.12).

Note 1 to entry: The grouping of assets may be by asset type (3.2.7), asset class, asset system (3.2.6) or asset portfolio (3.2.5).

Note 2 to entry: An asset management plan is derived from the strategic asset management plan (3.3.2).

Note 3 to entry: An asset management plan may be contained in, or may be a subsidiary plan of, the strategic asset management plan.

3.3.4 preventive action

action to eliminate the cause of a potential nonconformity (3.1.11) or other undesirable potential situation

Note 1 to entry: This definition is specific to asset management (3.3.1) activities only.

Note 2 to entry: There can be more than one cause for a potential nonconformity.
Note 3 to entry: Preventive action is taken to prevent occurrence and to preserve an asset’s (3.2.1) function, whereas corrective action (3.4.1) is taken to prevent recurrence.

Note 4 to entry: Preventive action is normally carried out while the asset is functionally available and operable or prior to the initiation of functional failure.

Note 5 to entry: Preventive action includes the replenishment of consumables where the consumption is a functional requirement (3.1.19).

[SOURCE: ISO 9000:2005, 3.6.4, modified – Note 3 to entry has been modified; Notes 1, 4 and 5 have been added]

3.3.5 predictive action
action to monitor the condition of an asset (3.2.1) and predict the need for preventive action (3.3.4) or corrective action (3.4.1)

Note 1 to entry: Predictive action is also commonly referred to as either “condition monitoring” or “performance monitoring”.

3.3.6 level of service
parameters, or combination of parameters, which reflect social, political, environmental and economic outcomes that the organization (3.1.13) delivers

Note 1 to entry: The parameters can include safety, customer satisfaction, quality, quantity, capacity, reliability, responsiveness, environmental acceptability, cost and availability.

3.4 Terms relating to asset management system

3.4.1 corrective action
action to eliminate the cause of a nonconformity (3.1.11) and to prevent recurrence

Note 1 to entry: In the case of other undesirable outcomes, action is necessary to minimize or eliminate the causes and to reduce the impact or prevent recurrence. Such actions fall outside the concept of corrective action, in the sense of this definition.

3.4.2 management system
set of interrelated or interacting elements of an organization (3.1.13) to establish policies (3.1.18) and objectives (3.1.12) and processes (3.1.19) to achieve those objectives

Note 1 to entry: A management system can address a single discipline or several disciplines.

Note 2 to entry: The system elements include the organization’s structure, roles and responsibilities, planning, operation, etc.

Note 3 to entry: The scope of a management system may include the whole of the organization, specific and identified functions of the organization, specific and identified sections of the organization, or one or more functions across a group of organizations.

3.4.3 asset management system
management system (3.4.2) for asset management (3.3.1) whose function is to establish the asset management policy (3.1.18) and asset management objectives (3.1.12)

Note 1 to entry: The asset management system is a subset of asset management.
Annex A
(informative)

Information on asset management activities

Relevant asset management subject areas addressed by other published international, regional, or national standards include, but are not limited to, the following:

— data management;
— condition monitoring;
— risk management;
— quality management;
— environmental management;
— systems and software engineering;
— life cycle costing;
— dependability (availability, reliability, maintainability, maintenance support);
— configuration management;
— terotechnology;
— sustainable development;
— inspection;
— non-destructive testing;
— pressure equipment;
— financial management;
— value management;
— shock and vibration;
— acoustics;
— qualification and assessment of personnel;
— project management;
— property and property management;
— facilities management;
— equipment management;
— commissioning process;
— energy management.

Users of ISO 55001, ISO 55002 and this International Standard should also refer to such standards wherever possible, to ensure consistent delivery of asset management throughout their organization.
Annex B  
(informative)

Relationship between key elements of an asset management system

Figure B.1 shows the relationship between key elements of an asset management system.

NOTE The grey highlighted box designates the boundary of the asset management system.

Figure B.1 — Relationship between key elements of an asset management system
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[4] ISO 14001, Environmental management systems — Requirements with guidance for use
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[10] ISO 20815, Petroleum, petrochemical and natural gas industries — Production assurance and reliability management
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# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>iv</td>
</tr>
<tr>
<td>Introduction</td>
<td>v</td>
</tr>
<tr>
<td>1  Scope</td>
<td>1</td>
</tr>
<tr>
<td>2  Normative reference</td>
<td>1</td>
</tr>
<tr>
<td>3  Terms and definitions</td>
<td>1</td>
</tr>
<tr>
<td>4  Context of the organization</td>
<td>1</td>
</tr>
<tr>
<td>4.1 Understanding the organization and its context</td>
<td>1</td>
</tr>
<tr>
<td>4.2 Understanding the needs and expectations of stakeholders</td>
<td>1</td>
</tr>
<tr>
<td>4.3 Determining the scope of the asset management system</td>
<td>2</td>
</tr>
<tr>
<td>4.4 Asset management system</td>
<td>2</td>
</tr>
<tr>
<td>5  Leadership</td>
<td>2</td>
</tr>
<tr>
<td>5.1 Leadership and commitment</td>
<td>2</td>
</tr>
<tr>
<td>5.2 Policy</td>
<td>3</td>
</tr>
<tr>
<td>5.3 Organizational roles, responsibilities and authorities</td>
<td>3</td>
</tr>
<tr>
<td>6  Planning</td>
<td>3</td>
</tr>
<tr>
<td>6.1 Actions to address risks and opportunities for the asset management system</td>
<td>3</td>
</tr>
<tr>
<td>6.2 Asset management objectives and planning to achieve them</td>
<td>4</td>
</tr>
<tr>
<td>7  Support</td>
<td>5</td>
</tr>
<tr>
<td>7.1 Resources</td>
<td>5</td>
</tr>
<tr>
<td>7.2 Competence</td>
<td>5</td>
</tr>
<tr>
<td>7.3 Awareness</td>
<td>6</td>
</tr>
<tr>
<td>7.4 Communication</td>
<td>6</td>
</tr>
<tr>
<td>7.5 Information requirements</td>
<td>6</td>
</tr>
<tr>
<td>7.6 Documented information</td>
<td>7</td>
</tr>
<tr>
<td>8  Operation</td>
<td>8</td>
</tr>
<tr>
<td>8.1 Operational planning and control</td>
<td>8</td>
</tr>
<tr>
<td>8.2 Management of change</td>
<td>8</td>
</tr>
<tr>
<td>8.3 Outsourcing</td>
<td>8</td>
</tr>
<tr>
<td>9  Performance evaluation</td>
<td>8</td>
</tr>
<tr>
<td>9.1 Monitoring, measurement, analysis and evaluation</td>
<td>8</td>
</tr>
<tr>
<td>9.2 Internal audit</td>
<td>9</td>
</tr>
<tr>
<td>9.3 Management review</td>
<td>9</td>
</tr>
<tr>
<td>10 Improvement</td>
<td>10</td>
</tr>
<tr>
<td>10.1 Nonconformity and corrective action</td>
<td>10</td>
</tr>
<tr>
<td>10.2 Preventive action</td>
<td>10</td>
</tr>
<tr>
<td>10.3 Continual improvement</td>
<td>11</td>
</tr>
<tr>
<td>Annex A (informative) Information on asset management activities</td>
<td>12</td>
</tr>
<tr>
<td>Bibliography</td>
<td>13</td>
</tr>
</tbody>
</table>

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO’s adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Project Committee ISO/PC 251, Asset management.
Introduction

This International Standard specifies the requirements for the establishment, implementation, maintenance and improvement of a management system for asset management, referred to as an “asset management system”.

This International Standard can be used by any organization. The organization determines to which of its assets this International Standard applies.

This International Standard is primarily intended for use by:

— those involved in the establishment, implementation, maintenance and improvement of an asset management system;
— those involved in delivering asset management activities and service providers;
— internal and external parties to assess the organization's ability to meet legal, regulatory and contractual requirements and the organization's own requirements.

The order in which requirements are presented in this International Standard does not reflect their importance or imply the order in which they are to be implemented.

Further guidance regarding the application of the requirements within this International Standard is provided in ISO 55002.

General information on asset management, and information on the terminology applicable to this International Standard, is provided in ISO 55000. Organizations can find that consideration of the principles will assist the development of asset management in their organization.

This International Standard applies the definition of “risk” given in ISO 31000:2009 and ISO Guide 73:2009. In addition, it uses the term “stakeholder” rather than “interested party”.

This International Standard is designed to enable an organization to align and integrate its asset management system with related management system requirements.

Annex A provides additional information on areas related to asset management activities.
Asset management — Management systems — Requirements

1 Scope
This International Standard specifies requirements for an asset management system within the context of the organization.

This International Standard can be applied to all types of assets and by all types and sizes of organizations.

NOTE 1 This International Standard is intended to be used for managing physical assets in particular, but it can also be applied to other asset types.

NOTE 2 This International Standard does not specify financial, accounting or technical requirements for managing specific asset types.

NOTE 3 For the purposes of ISO 55000, ISO 55002 and this International Standard, the term “asset management system” is used to refer to a management system for asset management.

2 Normative reference
The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 55000:2014, Asset management — Overview, principles and terminology

3 Terms and definitions
For the purposes of this document, the terms and definitions given in ISO 55000 apply.

4 Context of the organization

4.1 Understanding the organization and its context
The organization shall determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended outcome(s) of its asset management system.

Asset management objectives, included in the strategic asset management plan (SAMP), shall be aligned to, and consistent with, the organizational objectives.

4.2 Understanding the needs and expectations of stakeholders
The organization shall determine:

— the stakeholders that are relevant to the asset management system;
— the requirements and expectations of these stakeholders with respect to asset management;
— the criteria for asset management decision making;
— the stakeholder requirements for recording financial and non-financial information relevant to asset management, and for reporting on it both internally and externally.
4.3 Determining the scope of the asset management system

The organization shall determine the boundaries and applicability of the asset management system to establish its scope. The scope shall be aligned with the SAMP and the asset management policy. When determining this scope, the organization shall consider:

- the external and internal issues referred to in 4.1;
- the requirements referred to in 4.2;
- the interaction with other management systems, if used.

The organization shall define the asset portfolio covered by the scope of the asset management system.

The scope shall be available as documented information.

4.4 Asset management system

The organization shall establish, implement, maintain and continually improve an asset management system, including the processes needed and their interactions, in accordance with the requirements of this International Standard.

The organization shall develop a SAMP which includes documentation of the role of the asset management system in supporting achievement of the asset management objectives.

5 Leadership

5.1 Leadership and commitment

Top management shall demonstrate leadership and commitment with respect to the asset management system by:

- ensuring that the asset management policy, the SAMP and asset management objectives are established and are compatible with the organizational objectives;
- ensuring the integration of the asset management system requirements into the organization's business processes;
- ensuring that the resources for the asset management system are available;
- communicating the importance of effective asset management and of conforming to the asset management system requirements;
- ensuring that the asset management system achieves its intended outcome(s);
- directing and supporting persons to contribute to the effectiveness of the asset management system;
- promoting cross-functional collaboration within the organization;
- promoting continual improvement;
- supporting other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility;
- ensuring that the approach used for managing risk in asset management is aligned with the organization's approach for managing risk.

NOTE Reference to “business” in this International Standard can be interpreted broadly to mean those activities that are core to the purposes of the organization's existence.
5.2 Policy

Top management shall establish an asset management policy that:

a) is appropriate to the purpose of the organization;

b) provides a framework for setting asset management objectives;

c) includes a commitment to satisfy applicable requirements;

d) includes a commitment to continual improvement of the asset management system.

The asset management policy shall:

— be consistent with the organizational plan;
— be consistent with other relevant organizational policies;
— be appropriate to the nature and scale of the organization’s assets and operations;
— be available as documented information;
— be communicated within the organization;
— be available to stakeholders, as appropriate;
— be implemented and be periodically reviewed and, if required, updated.

5.3 Organizational roles, responsibilities and authorities

Top management shall ensure that the responsibilities and authorities for relevant roles are assigned and communicated within the organization.

Top management shall assign the responsibility and authority for:

a) establishing and updating the SAMP, including asset management objectives;

b) ensuring that the asset management system supports delivery of the SAMP;

c) ensuring that the asset management system conforms to the requirements of this International Standard;

d) ensuring the suitability, adequacy and effectiveness of the asset management system;

e) establishing and updating the asset management plan(s) (see 6.2.2);

f) reporting on the performance of the asset management system to top management.

6 Planning

6.1 Actions to address risks and opportunities for the asset management system

When planning for the asset management system, the organization shall consider the issues referred to in 4.1 and the requirements referred to in 4.2 and determine the risks and opportunities that need to be addressed to:

— give assurance that the asset management system can achieve its intended outcome(s);
— prevent, or reduce undesired effects;
— achieve continual improvement.
The organization shall plan:

a) actions to address these risks and opportunities, taking into account how these risks and opportunities can change with time;

b) how to:
   — integrate and implement the actions into its asset management system processes;
   — evaluate the effectiveness of these actions.

### 6.2 Asset management objectives and planning to achieve them

#### 6.2.1 Asset management objectives

The organization shall establish asset management objectives at relevant functions and levels.

When establishing its asset management objectives, the organization shall consider the requirements of relevant stakeholders and of other financial, technical, legal, regulatory and organizational requirements in the asset management planning process.

The asset management objectives shall:

— be consistent and aligned with the organizational objectives;
— be consistent with the asset management policy;
— be established and updated using asset management decision-making criteria (see 4.2);
— be established and updated as part of the SAMP;
— be measurable (if practicable);
— take into account applicable requirements;
— be monitored;
— be communicated to relevant stakeholders;
— be reviewed and updated as appropriate.

The organization shall retain documented information on the asset management objectives.

#### 6.2.2 Planning to achieve asset management objectives

The organization shall integrate the planning to achieve asset management objectives with other organizational planning activities, including financial, human resources and other support functions.

The organization shall establish, document and maintain asset management plan(s) to achieve the asset management objectives. These asset management plan(s) shall be aligned with the asset management policy and the SAMP.

The organization shall ensure that the asset management plan(s) take(s) into account relevant requirements coming from outside the asset management system.

When planning how to achieve its asset management objectives, the organization shall determine and document:

a) the method and criteria for decision making and prioritizing of the activities and resources to achieve its asset management plan(s) and asset management objectives;

b) the processes and methods to be employed in managing its assets over their life cycles;
c) what will be done;
d) what resources will be required;
e) who will be responsible;
f) when it will be completed;
g) how the results will be evaluated;
h) the appropriate time horizon(s) for the asset management plan(s);
i) the financial and non-financial implications of the asset management plan(s);
j) the review period for the asset management plan(s) (see 9.1);
k) actions to address risks and opportunities associated with managing the assets, taking into account
how these risks and opportunities can change with time, by establishing processes for:
  — identification of risks and opportunities;
  — assessment of risks and opportunities;
  — determining the significance of assets in achieving asset management objectives;
  — implementation of the appropriate treatment, and monitoring, of risks and opportunities.

The organization shall ensure that its asset management related risks are considered in the organization’s
risk management approach including contingency planning.

NOTE See ISO 31000 for further guidance on risk management

7 Support

7.1 Resources

The organization shall determine and provide the resources needed for the establishment,
implementation, maintenance and continual improvement of the asset management system.

The organization shall provide the resources required for meeting the asset management objectives and
for implementing the activities specified in the asset management plan(s).

7.2 Competence

The organization shall:
  — determine the necessary competence of person(s) doing work under its control that affects its asset
    performance, asset management performance and asset management system performance;
  — ensure that these persons are competent on the basis of appropriate education, training, or
    experience;
  — where applicable, take actions to acquire the necessary competence, and evaluate the effectiveness
    of the actions taken;
  — retain appropriate documented information as evidence of competence;
  — periodically review current and future competency needs and requirements.

NOTE Applicable actions can include, for example: the provision of training to, the mentoring of, or the re-
assignment of currently employed persons; or the hiring or contracting of competent persons.
7.3 Awareness

Persons doing work under the organization's control, who can have an impact on the achievement of the asset management objectives, shall be aware of:

— the asset management policy;
— their contribution to the effectiveness of the asset management system, including the benefits of improved asset management performance;
— their work activities, the associated risks and opportunities and how they relate to each other;
— the implications of not conforming to the asset management system requirements.

7.4 Communication

The organization shall determine the need for internal and external communications relevant to assets, asset management and the asset management system including:

— on what it will communicate;
— when to communicate;
— with whom to communicate;
— how to communicate.

7.5 Information requirements

The organization shall determine its information requirements to support its assets, asset management, asset management system and the achievement of its organizational objectives. In doing this:

a) the organization shall include consideration of:
   — the significance of the identified risks;
   — the roles and responsibilities for asset management;
   — the asset management processes, procedures and activities;
   — the exchange of information with its stakeholders, including service providers;
   — the impact of quality, availability and management of information on organizational decision making;

b) the organization shall determine:
   — the attribute requirements of identified information;
   — the quality requirements of identified information;
   — how and when information is to be collected, analysed and evaluated;

c) the organization shall specify, implement and maintain processes for managing its information;

d) the organization shall determine the requirements for alignment of financial and non-financial terminology relevant to asset management throughout the organization;

e) the organization shall ensure that there is consistency and traceability between the financial and technical data and other relevant non-financial data, to the extent required to meet its legal and regulatory requirements while considering its stakeholders' requirements and organizational objectives.
7.6 Documented information

7.6.1 General

The organization’s asset management system shall include:

— documented information as required by this International Standard;
— documented information for applicable legal and regulatory requirements;
— documented information determined by the organization as being necessary for the effectiveness of the asset management system, as specified in 7.5.

NOTE The extent of the documented information for an asset management system can differ from one organization to another due to:

— the size of organization and its type of activities, processes, products and services;
— the complexity of processes and their interactions;
— the competence of persons;
— the complexity of the asset(s).

7.6.2 Creating and updating

When creating and updating documented information the organization shall ensure appropriate:

— identification and description (e.g. a title, date, author, or reference number);
— format (e.g. language, software version, graphics) and media (e.g. paper, electronic);
— review and approval for suitability and adequacy.

7.6.3 Control of documented information

Documented information required by the asset management system and by this International Standard shall be controlled to ensure:

a) it is available and suitable for use, where and when it is needed;

b) it is adequately protected (e.g. from loss of confidentiality, improper use, or loss of integrity).

For the control of documented information, the organization shall address the following activities, as applicable:

— distribution, access, retrieval and use;
— storage and preservation, including preservation of legibility;
— control of changes (e.g. version control);
— retention and disposition.

Documented information of external origin determined by the organization to be necessary for the planning and operation of the asset management system shall be identified, as appropriate, and controlled.

NOTE Access implies a decision regarding the permission to view the documented information only, or the permission and authority to view and change the documented information, etc.
8 Operation

8.1 Operational planning and control

The organization shall plan, implement and control the processes needed to meet requirements, and to implement the actions determined in 6.1, the asset management plan(s) determined in 6.2, and the corrective and preventive actions determined in 10.1 and 10.2 by:

— establishing criteria for the required processes;
— implementing the control of the processes in accordance with the criteria;
— keeping documented information to the extent necessary to have confidence and evidence that the processes have been carried out as planned;
— treating and monitoring risks using the approach described in 6.2.2.

8.2 Management of change

Risks associated with any planned change, permanent or temporary that can have an impact on achieving the asset management objectives, shall be assessed before the change is implemented.

The organization shall ensure that such risks are managed in accordance with 6.1 and 6.2.2.

The organization shall control planned changes and review the unintended consequences of changes, taking action to mitigate any adverse effects, as necessary.

8.3 Outsourcing

When the organization outsources any activities that can have an impact on the achievement of its asset management objectives, it shall assess the associated risks. The organization shall ensure that outsourced processes and activities are controlled.

The organization shall determine and document how these activities will be controlled and integrated into the organization's asset management system. The organization shall determine:

a) the processes and activities that are to be outsourced (including the scope and boundaries of the outsourced processes and activities and their interfaces with the organization's own processes and activities);

b) the responsibilities and authorities within the organization for managing the outsourced processes and activities;

c) the processes and scope for the sharing of knowledge and information between the organization and its contracted service provider(s);

When outsourcing any activities, the organization shall ensure that:

— the outsourced resources meet the requirements of 7.2, 7.3 and 7.6;
— the performance of the outsourced activities is monitored in accordance with 9.1.

9 Performance evaluation

9.1 Monitoring, measurement, analysis and evaluation

The organization shall determine:

a) what needs to be monitored and measured;
b) the methods for monitoring, measurement, analysis and evaluation, as applicable, to ensure valid results;

c) when the monitoring and measuring shall be performed;

d) when the results from monitoring and measurement shall be analysed and evaluated.

The organization shall evaluate and report on

— the asset performance;

— the asset management performance, including financial and non-financial performance;

— the effectiveness of the asset management system.

The organization shall evaluate and report on the effectiveness of the processes for managing risks and opportunities.

The organization shall retain appropriate documented information as evidence of the results of monitoring, measurement, analysis and evaluation.

The organization shall ensure that its monitoring and measurement enables it to meet the requirements of 4.2.

### 9.2 Internal audit

#### 9.2.1 The organization shall conduct internal audits at planned intervals to provide information to assist in the determination on whether the asset management system:

a) conforms to:
   — the organization's own requirements for its asset management system;
   — the requirements of this International Standard;

b) is effectively implemented and maintained.

#### 9.2.2 The organization shall:

a) plan, establish, implement and maintain an audit programme(s), including the frequency, methods, responsibilities, planning requirements and reporting. The audit programme(s) shall take into consideration the importance of the processes concerned and the results of previous audits;

b) define the audit criteria and scope for each audit;

c) select auditors and conduct audits to ensure objectivity and the impartiality of the audit process;

d) ensure that the results of the audits are reported to relevant management; and

e) retain documented information as evidence of the results of the implementation of the audit programme and the audit results.

### 9.3 Management review

Top management shall review the organization's asset management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness.

The management review shall include consideration of:

a) the status of actions from previous management reviews;

b) changes in external and internal issues that are relevant to the asset management system;
c) information on the asset management performance, including trends in:
   — nonconformities and corrective actions;
   — monitoring and measurement results;
   — audit results;

d) asset management activity;

e) opportunities for continual improvement;

f) changes in the profile of risks and opportunities.

The outputs of the management review shall include decisions related to continual improvement opportunities and any need for changes (see 8.2) to the asset management system.

The organization shall retain documented information as evidence of the results of management reviews.

10 Improvement

10.1 Nonconformity and corrective action

When a nonconformity or incident occurs in its assets, asset management or asset management system the organization shall:

a) react to the nonconformity or incident, and, as applicable:
   — take action to control and correct it;
   — deal with the consequences;

b) evaluate the need for action to eliminate the causes of the nonconformity or incident, in order that it does not occur or recur elsewhere, by:
   — reviewing the nonconformity or incident;
   — determining the causes of nonconformity or incident;
   — determining if similar nonconformities exist, or could potentially occur;

c) implement any action needed;

d) review the effectiveness of any corrective action taken; and

e) make changes (see 8.2) to the asset management system, if necessary.

Corrective actions shall be appropriate to the effects of the nonconformities or incident encountered.

The organization shall retain documented information as evidence of:

— the nature of the nonconformities or incident and any subsequent actions taken;
— the results of any corrective action.

10.2 Preventive action

The organization shall establish processes to proactively identify potential failures in asset performance and evaluate the need for preventive action.

When a potential failure is identified the organization shall apply the requirements of 10.1.
10.3 Continual improvement

The organization shall continually improve the suitability, adequacy and effectiveness of its asset management and the asset management system.
Annex A
(informative)

Information on asset management activities

Relevant asset management subject areas addressed by other published international, regional, or national standards include, but are not limited to, the following:

— data management;
— condition monitoring;
— risk management;
— quality management;
— environmental management;
— systems and software engineering;
— life cycle costing;
— dependability (availability, reliability, maintainability, maintenance support);
— configuration management;
— tero-technology;
— sustainable development;
— inspection;
— non-destructive testing;
— pressure equipment;
— financial management;
— value management;
— shock and vibration;
— acoustics;
— qualification and assessment of personnel;
— project management;
— property and property management;
— facilities management;
— equipment management;
— commissioning process;
— energy management.

Users of ISO 55000, ISO 55002 and this International Standard should also refer to such standards wherever possible, to ensure consistent delivery of asset management throughout their organization.
Bibliography

[1] ISO 9000, Quality management systems — Fundamentals and vocabulary
[2] ISO 9001, Quality management systems — Requirements
[4] ISO 14001, Environmental management systems — Requirements with guidance for use
[8] ISO 17359, Condition monitoring and diagnostics of machines — General guidelines
[9] ISO 19011, Guidelines for auditing management systems
[10] ISO 20815, Petroleum, petrochemical and natural gas industries — Production assurance and reliability management
[12] ISO 22301, Societal security — Business continuity management systems — Requirements
[14] ISO 37500, Guidance on outsourcing
[19] IEC 31010, Risk management — Risk assessment techniques
[22] ASTM E2132, Standard Practice for Inventory Verification: Electronic and Physical Inventory of Assets

1) Under preparation.


Asset management — Management systems — Guidelines for the application of ISO 55001

Gestion d'actifs — Systèmes de management — Lignes directrices relatives à l’application de l’ISO 55001
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>iv</td>
</tr>
<tr>
<td>Introduction</td>
<td>v</td>
</tr>
<tr>
<td>1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>2 Normative references</td>
<td>1</td>
</tr>
<tr>
<td>3 Terms and definitions</td>
<td>1</td>
</tr>
<tr>
<td>4 Context of the organization</td>
<td>1</td>
</tr>
<tr>
<td>4.1 Understanding the organization and its context</td>
<td>1</td>
</tr>
<tr>
<td>4.2 Understanding the needs and expectations of stakeholders</td>
<td>4</td>
</tr>
<tr>
<td>4.3 Determining the scope of the asset management system</td>
<td>5</td>
</tr>
<tr>
<td>4.4 Asset management system</td>
<td>5</td>
</tr>
<tr>
<td>5 Leadership</td>
<td>6</td>
</tr>
<tr>
<td>5.1 Leadership and commitment</td>
<td>6</td>
</tr>
<tr>
<td>5.2 Policy</td>
<td>7</td>
</tr>
<tr>
<td>5.3 Organizational roles, responsibilities and authorities</td>
<td>7</td>
</tr>
<tr>
<td>6 Planning</td>
<td>8</td>
</tr>
<tr>
<td>6.1 Actions to address risks and opportunities for the asset management system</td>
<td>8</td>
</tr>
<tr>
<td>6.2 Asset management objectives and planning to achieve them</td>
<td>8</td>
</tr>
<tr>
<td>7 Support</td>
<td>13</td>
</tr>
<tr>
<td>7.1 Resources</td>
<td>13</td>
</tr>
<tr>
<td>7.2 Competence</td>
<td>14</td>
</tr>
<tr>
<td>7.3 Awareness</td>
<td>15</td>
</tr>
<tr>
<td>7.4 Communication</td>
<td>16</td>
</tr>
<tr>
<td>7.5 Information requirements</td>
<td>16</td>
</tr>
<tr>
<td>7.6 Documented information</td>
<td>18</td>
</tr>
<tr>
<td>8 Operation</td>
<td>18</td>
</tr>
<tr>
<td>8.1 Operational planning and control</td>
<td>18</td>
</tr>
<tr>
<td>8.2 Management of change</td>
<td>19</td>
</tr>
<tr>
<td>8.3 Outsourcing</td>
<td>20</td>
</tr>
<tr>
<td>9 Performance evaluation</td>
<td>21</td>
</tr>
<tr>
<td>9.1 Monitoring, measurement, analysis and evaluation</td>
<td>21</td>
</tr>
<tr>
<td>9.2 Internal audit</td>
<td>24</td>
</tr>
<tr>
<td>9.3 Management review</td>
<td>25</td>
</tr>
<tr>
<td>10 Improvement</td>
<td>26</td>
</tr>
<tr>
<td>10.1 Nonconformity and corrective action</td>
<td>26</td>
</tr>
<tr>
<td>10.2 Preventive action</td>
<td>27</td>
</tr>
<tr>
<td>10.3 Continual improvement</td>
<td>27</td>
</tr>
<tr>
<td>Annex A (informative) Information on asset management activities</td>
<td>29</td>
</tr>
<tr>
<td>Annex B (informative) Relationship between key elements of an asset management system</td>
<td>30</td>
</tr>
<tr>
<td>Bibliography</td>
<td>31</td>
</tr>
</tbody>
</table>
Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Project Committee ISO/PC 251, Asset management.
Introduction

This International Standard provides guidance for the application of a management system for asset management, referred to as an “asset management system”, in accordance with the requirements of ISO 55001.

This International Standard contains explanatory text necessary to clarify the requirements specified in ISO 55001 and provides examples to support implementation. It does not provide guidance for managing specific asset types.

This International Standard provides guidance for use by:

— those involved in the establishment, implementation, maintenance and improvement of an asset management system;

— those involved in delivering asset management activities and service providers.

General information on asset management, and information on the terminology applicable to this International Standard, is provided in ISO 55000.

Annex A provides additional information on areas related to asset management activities.

Annex B shows the relationship between key elements of an asset management system.
Asset management — Management systems — Guidelines for the application of ISO 55001

1 Scope
This International Standard provides guidance for the application of an asset management system, in accordance with the requirements of ISO 55001.

This International Standard can be applied to all types of assets and by all types and sizes of organizations.

NOTE 1 This International Standard is intended to be used for managing physical assets in particular, but it can also be applied to other asset types.

NOTE 2 This International Standard does not provide financial, accounting or technical guidance for managing specific asset types.

NOTE 3 For the purposes of ISO 55000, ISO 55001 and this International Standard, the term “asset management system” is used to refer to a management system for asset management.

2 Normative references
The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 55000:2014, Asset management — Overview, principles and terminology
ISO 55001:2014, Asset management — Management systems — Requirements

3 Terms and definitions
For the purposes of this document, the terms and definitions given in ISO 55000 apply.

4 Context of the organization

4.1 Understanding the organization and its context

4.1.1 Overview

4.1.1.1 The asset management system forms an integrated part of the organization’s management system and has a prescribed structure. It should fit in and result from:

— the organizational objectives;
— the organizational plan.

The asset management system includes:

a) the asset management policy (see 5.2);
b) the asset management objectives (see 6.2);
c) the strategic asset management plan (SAMP);
d) the asset management plan(s) (see 6.2.2), which are implemented in:
   — operational planning and control;
   — supporting activities;
   — control activities;
   — other relevant processes.

Figure B.1 shows the relationship between the key elements of an asset management system, together with the related clauses in ISO 55001.

The scope of an organization's asset management system and the outputs from its asset management activities should be used to set out the approach to enable the delivery of its organizational objectives. The requirements for the scope and context of an organization's asset management system are given in ISO 55001:2014, Clause 4.

The organizational objectives provide the overarching context and direction to the organization's activities, including its asset management activities. The organizational objectives are generally produced from the organization's strategic level planning activities and are documented in an organizational plan.

NOTE 1 The organizational plan can be referred to by other names, e.g. the corporate plan.

The principles by which the organization intends applying asset management to achieve its organizational objectives should be set out in an asset management policy. The approach to implementing these principles should be documented in a strategic asset management plan (SAMP).

NOTE 2 A strategic asset management plan can be referred to by other names, e.g. an asset management strategy.

The SAMP should document the relationship between the organizational objectives and the asset management objectives, and should define the framework required to achieve the asset management objectives.

The links between the organizational plan and the SAMP should be two-way, and should be developed through an iterative process. For example, the organizational objectives should not be developed in isolation from the organization's asset management activities. Asset capability and performance, as well as the outputs from asset management activities (e.g. the asset management plan(s)), are key inputs into establishing realistic and achievable organizational objectives.

4.1.1.2 In developing its SAMP, the organization should:

a) consider the expectations and requirements of stakeholders;

b) consider activities that could extend beyond the organization's routine planning timeframe, and which should be subject to regular review;

c) clearly document the processes to establish its asset-related decision-making criteria.

The SAMP should be a high level plan that contains the asset management objectives. It should be used to develop the asset management plan(s), which should set out the asset level activities. The asset management plan(s) can be cascaded in large organizations or in organizations with complex asset portfolios.

4.1.1.3 All parts of the asset management system should be scalable, e.g. for small organizations, the organizational plan could be a single document that includes separate sections for:

a) the organizational objectives;

b) the SAMP;
the asset management plan(s).

Alternatively, the organizational plan could be kept separate from the SAMP, which could include the asset management plan(s) as a sub-section, or all three plans could be kept separately. While it is necessary to distinguish between the SAMP and the asset management plan(s), it is not a requirement of ISO 55001 to create separate documents for each.

The concept of ensuring alignment and consistency between the organizational objectives, the asset management policy, the SAMP, the asset management objectives and the asset management plan(s), should reinforce within the organization that asset level activities support the delivery of the organizational objectives. It is important that this alignment is communicated to ensure that stakeholders at all levels understand why asset activities and asset management activities are implemented.

4.1.2 Understanding the organization and its context

4.1.2.1 When establishing or reviewing an asset management system, it is important to ensure that the approach is consistent and aligned with the external and internal contexts of the organization, since these can significantly influence the design and scope of the asset management system.

4.1.2.2 Evaluating the organization’s external context can include, but is not limited to, the following issues:

a) the social and cultural, political, legal, regulatory, financial, technological, economic, competitive and natural environment, whether international, national, regional or local;

b) key drivers and trends having impacts on the objectives of the organization;

c) relationships with, and perceptions and values of, external stakeholders.

4.1.2.3 Evaluating the organization’s internal context can include, but is not limited to, the following issues:

a) governance requirements;

b) organizational structure, roles, accountabilities and authorities;

c) policies, objectives, and the strategies that are in place to achieve them;

d) capabilities, understood in terms of resources and knowledge (e.g. capital, time, people, systems and technologies);

e) information systems, information flows and decision-making processes (both formal and informal);

f) relationships with, and perceptions and values of, internal stakeholders;

g) the organization’s culture;

b) standards, guidelines and models adopted by the organization;

i) the form and extent of contractual relationships;

j) risk management plans;

k) asset management practices and other management systems, plans, process(es) and procedure(s);

l) integrity and performance of the assets and asset systems;

m) feedback from the investigation of previous asset and asset system failures, incidents, accidents and emergencies;
n) assessing the ability of the asset management system to achieve the intended outcomes of the organizational objectives;
o) feedback from previous self-assessments, internal audits, third party reviews and certification reviews.

4.2 Understanding the needs and expectations of stakeholders

4.2.1 The organization should identify and review the stakeholders that are relevant to asset management and the needs and expectations of these stakeholders.

4.2.2 Internal stakeholders can include the following:
a) employees within the organization;
b) groups within the organization, i.e. functional groups (e.g. engineering, accounting, maintenance, operations, purchasing, receiving, logistics) or other groups (e.g. safety delegates);
c) shareholders, management consortia, owners.

4.2.3 External stakeholders can include the following:
a) customers, users, suppliers, service providers and contractors;
b) non-governmental organizations, including civil society organizations, consumer organizations and the media with an interest in issues related to asset management;
c) government organizations, government agencies, regulatory authorities, and politicians at all levels of government;
d) investors or taxpayers;
e) local communities;
f) those in society interested in social, financial, environmental or other forms of sustainability;
g) financial institutions, rating agencies, and insurers;
h) employee representatives.

4.2.4 Stakeholders’ needs and expectations should be documented and communicated. This may be captured in a statement of stakeholders needs within the SAMP and should reference any mandatory requirements, as well as the expectations of different stakeholder groups. The organization should consider a means of tracking how current the information is, and the methods involved for its collection. When engaging with stakeholders to determine their needs and expectations, the organization can use the list of contexts given in 4.1.2 to frame the discussions.

One objective of asset management is to enable the organization to meet the service needs of the customers and users of its asset(s). The organization should measure the levels of service (see 6.2.1) that its assets deliver, and analyse these against the requirements and expectations of its customers and users. A level of service review process can be a useful approach to understand the expectations of customers and users.

Stakeholders are likely to make judgments about the organization’s asset management and its asset management outputs and outcomes, based on their perceptions. These can vary due to differences in values, needs, assumptions, concepts and concerns, as they relate to the issues under discussion. Since the views of stakeholders can have a significant impact on the organization’s asset-related decisions, it is important that their perceptions are determined, recorded, and taken into account in the organization’s decision-making process.
Understanding how asset-related decisions are made is an important part of asset management. The criteria for decision making are influenced by the needs of external and internal stakeholders, by the asset management policy and by the risk attitude of the organization. The external and internal stakeholders' input to establishing decision-making criteria is important for setting priorities and resolving conflicting requirements. Decision-making criteria should be appropriate to the importance and complexity of the decisions being made. Decision-making criteria should be used to evaluate competing options to meet asset management objectives and develop asset management plans. The criteria can be expressed in a number of ways, to support quantitative, semi-quantitative or qualitative decisions. The processes to establish the decision-making criteria that guide asset management should be clear and documented.

The level of detail needed when reporting to stakeholders will vary from one stakeholder to another, depending on the scope of the organization's activities and on the complexity of the assets being managed. The detail should only disclose proprietary information as appropriate for the stakeholders receiving the information.

Stakeholders generally need to be informed about the decisions that can affect them and might need to provide input into decisions that can have an impact on them. Failure to both communicate and consult in an appropriate way about asset management activities can in itself constitute a risk, because it could later prevent an organization from fulfilling its objectives.

It is important that the terminology used in communicating with stakeholders is consistent and aligned with other functions in the organization, and in accordance with legal requirements, where applicable. This is particularly necessary when communicating financial information.

4.3 Determining the scope of the asset management system

Based on the outcomes of reviews of its context and stakeholders (see 4.1 and 4.2), the organization should define (or review) the boundaries of the asset management system, and establish its scope.

The boundaries and applicability of the asset management system should be captured in a statement of scope (which may be included in the SAMP). It should be communicated to all relevant stakeholders, both internal and external to the organization. The detail will be influenced by the size of the organization and the scale and complexity of the asset portfolio covered by the asset management system. It should clearly show what is considered inside and outside scope.

The scope should consider:

a) the assets, asset portfolio(s), their boundaries and interdependencies;
b) which other organizations are involved in meeting the organization’s asset management system requirements (including the requirements of ISO 55001), e.g. through the outsourcing of asset management activities or activities related to life cycle stages;
c) the organizational aspects, e.g. which parts or functions of the organization are involved;
d) the organization's period of responsibility (e.g. where the management of assets is contracted out for a set period of time), including its residual liabilities beyond the operation or use of the asset (e.g. where an organization remains accountable for risks beyond its use of an asset, such as a chemical plant asset owner that retains liability for ground contamination);
e) the interactions with other parts of the organization's management system (e.g. for quality or environmental management), which can require defining the boundaries, functions, and responsibilities of each part of the management system.

4.4 Asset management system

In the initial development of the asset management system, the organization should outline how it will establish, implement, maintain and improve the system. An initial review of the organization’s current processes against the requirements of ISO 55001 will determine the areas that need to be developed to support the functioning of a compliant asset management system.
The asset management system should not stand alone. A factor of successful asset management is the ability to integrate asset management processes, activities and data with those of other organizational functions, e.g. quality, accounting, safety, risk and human resources. Where possible, existing business processes should be leveraged to avoid unnecessary new work and duplication of existing work and data. These interactions with the existing processes need to be clearly communicated to all involved.

Consideration should be given to how to prioritize what to develop first, as there is usually a limit on resources available. The review can guide the organization in formulating plan(s) for implementing and prioritizing improvements to its asset management system.

An appropriate starting point is the establishment of an asset management policy, which often helps to provide focus for the organization and to identify its intentions. Following this, the organization should develop its SAMP.

It is important to be aware of, and to clarify, any variations in terminology between ISO 5500 and the terminology used in the organization’s common practice.

Compliance with all the requirements of ISO 55001 should be considered as achieving only the minimum starting point for an effective asset management system and should not be seen as the final goal.

5 Leadership

5.1 Leadership and commitment

Asset management leadership can be demonstrated by top management through positively influencing the organization (and in its execution of all the requirements of ISO 55001, and specifically the requirements of ISO 55001:2014, 5.1). Top management may appoint an individual to oversee the development, implementation, operation and continual improvement of an asset management system, however, it is important that ownership and accountability for asset management remains at the top management level.

Top management commitment to asset management can be demonstrated by:

a) making reference to asset management principles in communications;

b) engagement in setting the objectives and measures of success for the people responsible for the asset management system:

- by setting priorities for these objectives;
- by allocating appropriate resources for the achievement of these objectives;

c) establishing a strong collaborative work culture that is focused on delivering the asset management objectives;

d) using asset management related decision-making criteria for capital expenditures and other decisions;

e) supporting asset management related improvement activities;

f) supporting a management-development track that encourages and rewards time spent in roles associated with asset management and operation of the asset management system;

g) monitoring the asset management system performance and ensuring corrective or preventive actions, including opportunities for continual improvement;

h) assuring that asset management is considered at the same level of importance as safety, quality, environment, etc.;

i) addressing asset related risks and incorporating them into the organization’s risk management processes;
j) aligning asset management and the asset management system to other organizational functions through collaboration on achieving the organizational objectives;

k) aligning asset management and the asset management system to other organizational practices and management systems, e.g. including the organization's approach to risk management.

5.2 Policy

The asset management policy is a short statement that sets out the principles by which the organization intends to apply asset management to achieve its organizational objectives. The asset management policy should be authorized by top management and thereby demonstrate commitment to asset management.

The policy should set out the organization's commitments and expectations for decisions, activities and behaviour concerning asset management. It should be aligned to and demonstrate support for the organizational objectives. For example, an organizational objective to reduce capital investment could result in an asset management policy statement for adopting risk-based approaches to capital investment.

Examples of asset management policy principles may include commitments for:

a) guiding principles for asset management activities, e.g. service delivery objectives are to guide asset management practices and decisions;

b) adherence to applicable laws, legislation and regulations;

c) the provision of resources to deliver on asset management objectives and the structure or working of the organization to achieve the organizational objectives, e.g. asset planning and management is to be integrated with corporate and business planning, budgetary and reporting processes;

d) the decision-making criteria to be used, e.g. asset management decisions are to be based on evaluations of alternatives that take into account life cycle costs, benefits and risks of the asset;

e) reporting on asset and asset management performance;

f) long-term objectives, sustainable outcomes and stakeholder requirements;

g) continual improvement of the asset management system.

It is not necessary for the policy to be captured in a discrete document; it can be contained in other high level organizational policies or documents, e.g. it may be included in the SAMP. The important point is that it is communicable to the organization. If this can be demonstrated, a separate asset management policy document may not be required.

There should be processes in place to review and update the asset management policy, and to ensure that if the organization's external or internal context changes, the actions necessary to update the policy are also triggered.

5.3 Organizational roles, responsibilities and authorities

The responsibilities and authorities of key functions should be defined (see ISO 55001:2014, 5.3). This should include both internal and outsourced roles and responsibilities. The interfaces between organizational functions should be clearly established. This becomes more important in an outsourced environment.

It should be clear which role is responsible for which activity. This can be achieved through the development of job descriptions, or through including asset management responsibilities in existing job descriptions, or through the production of a documented organizational chart.

When assigning internal roles, consideration should be given to the following:

a) an individual's experience and competence (see 7.2);
b) support for the role through training and mentoring;

c) other workload requirements and their variability, which could impact the individual's ability to
deliver on asset management related objectives;

d) the individual being able to demonstrate an understanding of what the responsibilities mean in the
context of their role (e.g. this can be achieved through the signed acceptance of a job description).

In small or medium-sized organizations, multiple asset management functions may be assigned to one
individual. This does not change the need to communicate this to other stakeholders, or to clarify the
responsibility of the individual.

For contractors and external service providers, their responsibilities and the competence required
should be documented in the scope or elsewhere in contracts.

6 Planning

6.1 Actions to address risks and opportunities for the asset management system

The organization should determine the actions that are necessary for addressing risks when planning
for its asset management system (see also ISO 55001:2014, 6.1). In this International Standard, it is
assumed that the term “risk” also includes opportunities (see ISO 55000:2014, 3.1.21). The overall
purpose is to understand the cause, effect and likelihood of adverse events occurring, to manage such
risks to an acceptable level, and to provide an audit trail for the management of risks. The intent is
for the organization to ensure that the asset management system achieves its objectives, prevents or
reduces undesired effects, identifies opportunities, and achieves continual improvement.

When addressing risks in the asset management system, the organization should determine the risk
assessment criteria (e.g. likelihood and consequence, and risk attitude) within asset management
decision making for its asset management system (see 4.2). A risk matrix may be used as part of this
process.

The approach of managing risks associated with the asset management system should be aligned
with the organization's risk management approach and, where appropriate, this may include business
continuity planning and contingency planning. The organization should consider how managing risks in
its asset management system relate to other risk management processes in the organization (see 4.3).

The organization should determine and plan actions, and provide adequate resources, to address its
asset management system risks. For example, asset management risks could be incorporated into an
organization's divisional and project risk registers, with appropriate escalation mechanisms if they
cannot be addressed at the level at which they are raised.

The organization should integrate the actions identified to address these risks into the implementation
plan for the asset management system.

The organization should be able to demonstrate how it has evaluated the effectiveness of the actions
that it has taken to manage the risks identified in relation to the organizational objectives and decision-
making criteria.

6.2 Asset management objectives and planning to achieve them

6.2.1 Asset management objectives

6.2.1.1 The asset management objectives, derived as part of the SAMP, provide the essential link between
the organizational objectives and the asset management plan(s) that describe how those objectives are
going to be achieved. The asset management objectives transform the required outcomes (product or service) to be provided by the assets, into activities typically described in the asset management plan(s).

The asset management objectives should be tailored to suit each organization’s needs, which may include addressing subsets of objectives (e.g. for the asset management system, asset portfolios, the asset system and at asset level), and can vary for different functions carried out to meet stakeholder requirements. The organization should consider information or data from sources internal and external to the organization, including contractors, key suppliers, regulators or other stakeholders.

Asset management objectives should be specific, measurable, achievable, realistic and time-bound (i.e. “SMART” objectives). They can be both quantitative measurements (e.g. mean time between failure) and qualitative measurements (e.g. customer satisfaction).

The organization should consider the monitoring, measuring, analysing and evaluating needed to drive and support its decision making on improvement actions. When deciding what to measure, how to measure, what to analyse, etc., it is important for the organization to understand what type of behaviour and actions it wants to achieve from the asset management objectives before implementing them. The asset management objectives should be aligned to the organizational objectives and should promote collaboration with stakeholders.

6.2.1.2 During the development of its asset management objectives, the organization should:

a) review risks, including the potential impacts from the failure of
   — assets, or
   — the asset management activities on achieving asset management objectives, individually or in combination;

b) review the importance of assets related to their intended outcomes, objectives and product or service requirements;

c) check the applicability of the asset management objectives during the asset management planning process.

6.2.1.3 Typical issues, amongst others, that are addressed by objectives include the following:

a) for asset management:
   — total cost of ownership;
   — net present value;
   — return on capital employed;
   — performance against plan;
   — certification of the asset management system, or the assessment of asset management maturity (by benchmarking);
   — customer satisfaction scores;
   — society or reputation survey results;
   — environmental impact, e.g. carbon costs;
   — level of service;

b) for asset portfolios:
   — return on investment (or return on capital employed, or return on asset);
c) for asset systems:
   — asset system availability;
   — asset system performance (e.g. uptime, efficiency);
   — unit cost of product or service;

d) for assets:
   — reliability (mean time/distance between failures);
   — asset condition, performance, or health score;
   — life cycle costs;
   — life expectancy;
   — asset energy performance.

For large or complex asset management systems, the organization might also need to establish objectives for the asset management system itself.

6.2.1.4 Monitoring the performance of the organization's asset management, in terms of how well the asset management objectives and hence the organizational objectives are being met, is an important part of the asset management system (see 9.1). Deviations in performance should be used as inputs to revise the asset management objectives.

Asset management objectives should be subject to regular management review (see 9.3) and such reviews should inform the continuous improvement process (see 10.3).

6.2.2 Planning to achieve asset management objectives

6.2.2.1 The organization should develop an asset management plan(s) to define the activities that will be implemented and the resources that will be applied to meet the asset management objectives and consequently the organizational objectives. An asset management plan(s) provides the direction to, and expectations for, an individual asset or for a portfolio, group or class of assets.

An asset management plan(s) should be documented at a level that is appropriate to the organization and the degree of sophistication in its asset management approach. There is no set formula for what should be included or how it should be structured, however, it is common practice for such an asset management plan(s) to contain a rationale for asset management activities, operational and maintenance plans, capital investment (overhaul, renewal, replacement and enhancement) plans, and financial and resource plans, often based on a review of earlier achievements.

For some organizations, this may be captured in a single document, while for other organizations, multiple asset management plans may be appropriate. For example, a small municipality may produce one asset management plan for all of its assets, whereas a large rail organization may provide multiple plans for each asset class (e.g. stations, track, infrastructure), or a utility may provide multiple plans for different locations.

Asset management plan(s) should be developed to appropriate time horizons for the organization. The time horizons should meet the organization's needs and take account of the organization's period of responsibility and the life of its assets.

There can be benefits in developing the first asset management plan(s) as an interim plan as quickly as possible, using existing information. It helps the organization to understand the strengths and weaknesses of current asset management practices and to identify priorities for the development of future plan(s). It can also help avoid embarking on ambitious data collection exercises before needs are fully understood.
It is important for the organization to commit the resources that are identified in the asset management plan(s) as being necessary, in order to achieve its planned objectives. Implementation of the asset management plan(s) is an iterative process that involves resolving conflicts between what is planned and what can be afforded in terms of financial constraints. Once the financial implications arising from the asset management plan(s) have been quantified, linkages need to be established between the asset management plan(s) and the financial plans of the organization, and decisions should be made jointly about financial allocations.

Asset management plan(s) should be reviewed periodically to ensure continual alignment with the asset management objectives. Planning should also consider solutions that do not require additional assets to achieve the organizational objectives (e.g. it can be preferable to change demand for products or services by changing pricing rather than building new assets or providing more services).

There should be a regular assessment of the ability of the SAMP to support the achievement of the asset management objectives. The intent is to determine what the mismatch or gaps are and where they exist. This analysis should be used as input to management review and to an improvement process for the asset management system.

A risk ranking process can determine which assets have a significant potential to impact on the achievement of the asset management objectives, i.e. which are the critical assets.

6.2.2.2 When developing or reviewing asset management plan(s), the organization should consider:

a) who should be responsible for developing and implementing the asset management plan(s) and their continual improvement: writing the asset management plan(s) internally is useful for ensuring better commitment to the asset management planning process, however, resources and capabilities can be such that external support is required; it is important that staff are familiar with the objectives and approach, and have the opportunity to learn from the project when external resources are used;

b) who will read the asset management plan(s), what they will want to know and need to know: a tiered approach to asset management plan development can assist in targeting several user groups, e.g. the executive summary aimed at top management and the general public, the main body of the plan at top management and key stakeholders, and appendices for more technical information for service providers;

c) the environments in which the assets are operating or are intended to operate and the activities that are being performed either on individual assets, on various components, where inter-dependencies exist or combinations of activities occur on the same asset, or on multiple assets (i.e. whether this activity on this asset is worthwhile and, if so, when);

d) activity program requirements, which will typically also involve operational planning activities and implementation (see Clause 8);

e) the performance of the assets and the intended outcomes expected from implementation of asset management plan(s) in enabling the organization to achieve its asset management objectives;

f) whether appropriate resources and funding is available;

g) applicable standards.

6.2.2.3 The organization should ensure that its assets are capable of delivering the required products or services and achieving its organizational objectives.

The organization should be able to create and demonstrate a link between the actions that address the risks and the organization's approach to risk management and business continuity planning.

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When planning processes to manage risk in the asset management system, the organization should consider adopting a structured method for identifying, analysing and evaluating risk (see 6.1). An example method is provided below.

a) Classify assets and define the scope: prepare a list of asset systems and their constituent assets, and gather information about them, including the management and control activities which affect the assets’ performance; define the scope and limits of the individual asset risk assessments (see 4.3).

b) Identify risks: create a table of potential events and their causes, ensuring that the identification process includes risks to the delivery of the organizational objectives.

c) Identify risk controls that exist (or are proposed for planned assets and planned activities).

d) Analyse risks using appropriate process.

e) Evaluate the level of risk: estimate the likelihood and consequences for each potential event, based on the asset management decision-making criteria (see 4.2) and the risk management criteria (see 6.1). The effectiveness of any existing risk controls, and the likelihood and consequences of their failure, should also be considered.

f) Evaluate the level of risk over time: where appropriate, establish whether the identified risks will change over time, and how this will affect their consequences.

g) Evaluate the tolerability of the risks: decide whether planned or existing controls (if any) are sufficient to keep the risks under control and to meet any legal, statutory and other asset management requirements.

h) Determine the treatment of the risks: establish whether the risks will be treated by addressing them directly, avoiding, reducing, tolerating or transferring them.

6.2.2.4 The organization's method to identify, analyse and evaluate risk in the asset management system should be documented appropriately (see 7.6). The documentation of the risk management process in the asset management system may include the completion of a risk register, or another recording mechanism appropriate to the organization's risk management approach.

The organization should document the risks associated with asset management and incorporate risks critical to the achievement of the asset management objectives in its risk register. Larger organizations may need to use divisional or project risk registers, with appropriate escalation mechanisms if the risks cannot be addressed at the level at which they are raised.

The organization should establish governance arrangements for risk management in the asset management system (see 6.1). This includes audit of the risk management approach (see 9.2), and the review of risks by top management (see 9.3).

Where asset life cycle activities or asset management activities are outsourced as part of the organization's asset management approach, the organization should ensure that the asset management system includes control and management of risk (see 8.3).

Asset management plan(s) should consider the risks during the organization's period of responsibility, including any residual liabilities beyond the period of operation or use of the asset.

In the process of continual improvement, the organization should consider the risks that can change with time and how these could impact the asset management system in the future and plan to manage them. For example, asset deterioration related risks can change the asset management risks over time (e.g. corrosion of a pipeline), or currency exchange related risks can impact capital investments.

Standard risk management practices tend to overlook events that are very low probability/high consequence as not worth considering in detail. For example, extreme weather events do not occur often, but when they happen, asset managers tend to be inadequately prepared.
It is important that there be an additional dimension in the risk analysis to include the capability of the asset system to monitor and continually assess the probability of these rare, but potentially catastrophic, events. While the probability of such events can be very low, the organization should establish systems of monitoring indicators to identify when circumstances change abruptly, so that it can implement processes early to mitigate against them.

The organization should apply a common methodology for determining the financial implications of the asset management plan(s). Asset management planning should take into account the difference between the economic and technical aspects of assets.

Life cycle cost, which may include capital expenditure, financing and operational costs, should be considered in the decision-making process (see 4.2). The development of an asset management plan can involve making decisions that have short- and long-term effects. It can also involve consideration of all the asset's life cycle stages, and the potential impacts of a decision at one stage on a later stage.

When making asset management decisions, the organization should use a methodology that evaluates options of investing in new or existing assets, or operational alternatives (which could include, for example, financial solutions that do not require assets). Consideration should be given to the different effects of capital expenditure, operational expenses and any resulting pricing impacts upon the organization's products and services.

NOTE See ISO 31000 for further information on risk management and IEC 31010 for guidance on risk assessment techniques.

7 Support

7.1 Resources

During the development and implementation of the asset management system, including the asset management objectives and asset management plan(s), the organization should determine the required resources. The organization should map its available resources to its planned activities to determine any gaps. This gap analysis can be used as an input to determining options for resourcing the activities. This analysis applies across all asset management activities, could be extensive and can require prioritization and programme planning of many projects to close these gaps.

It is possible that a resourcing analysis, for the reconciliation of available budgets with funding, could determine that not all proposed asset management activities can be resourced as proposed. An iterative process to reconcile proposed activities with available resources should be used, and the criteria and processes for prioritizing asset management activities should be decided and the asset management plan(s) be revised to reflect the available resourcing and the timing that the resource is assigned.

In determining options for resourcing the activities, the organization should consider both internal and external resources. For human resources, options available can be affected by organizational policy and strategic plans on human resources, contracting-out or outsourcing. For non-human resources, availability of resources should include consideration of procurement options (e.g. lease, hire, purchase or otherwise acquire). Both human and other resourcing needs can be influenced by the nature and duration of the activities (e.g. one-off versus on-going).

In some organizations, these activities can require that other parts of the organization provide additional resources in order to support the primary asset management activity (e.g. additional staff). Those responsible for implementing the asset management activity should ensure that they have coordinated effectively, so that all parts of the organization are resourced appropriately.

Any tools, facilities or equipment that are required for the delivery and control of asset management activities should be defined and managed as assets, at a level of detail appropriate to their function and purpose.
7.2 Competence

7.2.1 Competency in asset management should be addressed at all levels of the organization in a way that ensures alignment between roles and levels and not just for those considered to be asset managers. For example, a competent trades person should be able to demonstrate clear competency in specific asset management related tasks (e.g., condition rating) and also have an understanding of the relationship of what they do to the asset management activities others undertake (e.g., the input of the condition rating activity into the determination of remaining useful asset life).

7.2.2 The organization should determine the competences required for all asset management roles and responsibilities, and the awareness, knowledge, understanding, skills and experience needed to fulfil them. The organization should map its current competences to its required competences to determine any gaps. This gap analysis can be used to develop asset management competency improvement and training plans, and enable the organization to incorporate specific asset management competences into its organizational competency framework, as considered appropriate.

For example, the gap analysis and the resulting competency improvement and training plans may include the following:

a) the assessment of competences for the role(s), responsibility(ies) and accountability(ies) to be undertaken for all stakeholders;

b) alignment to the organizational objectives as well as its asset management policy, asset management objectives, SAMP and asset management plan(s);

c) the creation of personal development programmes that identify the training, education, development and other support needed to attain the required competence;

d) the provision of training and mentoring, including the selection of suitable methods and materials;

e) knowledge and job sharing;

f) succession and knowledge management plans;

g) the hiring or contracting of competent persons;

h) the training of target groups;

i) documentation and monitoring of the training received;

j) the evaluation of the training received against defined training needs and requirements, in order to verify conformity with asset management system requirements.

All persons assigned roles and accountabilities within the organization that can have an impact on the asset management system should have those roles and accountabilities communicated to them, be provided with the training, education, development and other support needed to perform their role, and be able to demonstrate the competences required.

7.2.3 The organization should recognize that there is interdependency between its asset management competences, its organizational design and business processes. When undertaking a competency gap analysis, it should also consider undertaking a gap analysis of its organizational design and business processes and develop appropriate improvement plans, as necessary. For example, the organization could find it has competent asset managers that are disconnected from its business planning and budgeting function, which could impede its long range planning and investment decision making. Alternatively, the organization could discover that the majority of its asset management competences exist within one
individual, with no effective succession and knowledge management plans (a situation requiring urgent remedial action).

The organization should:

a) establish appropriate and effective processes for managing the competence of persons undertaking asset management work that affects its asset and asset management performance;

b) consider linking these processes to its existing human resource management and competency improvement processes;

c) establish processes to periodically review and update the asset management competency improvement and training plans.

In the event that the organization decides to outsource any aspect of the asset management system, the organization should ensure that the external resource providers can demonstrate competency against the required activities. The organization should, depending on the criticality of the activity, validate claims of competency, and have a process to ensure that any third party resource provider continues to provide competent resources.

7.3 Awareness

7.3.1 Persons working under the organization’s control should have appropriate awareness of the organization’s asset management system and activities. Such persons can include staff, contractors, internal or external service providers, and suppliers. They should be aware of the asset management policy and the following:

a) why asset management is important to the organization;

b) the implications of changes in the operation of the organization (e.g. if the organization makes changes to its operational processes or performance objectives, those persons with accountability for the asset management system should be aware of any resulting impacts);

c) their contribution to the effectiveness of the asset management system, including the benefits of improved asset management system performance;

d) asset management related risk consequences (actual or potential) of their work activities, their behaviour, and the asset management benefits of improved personal performance and how they relate to each other;

e) their roles, responsibilities and authorities as well as the importance of their contribution in meeting the requirements of the asset management policy and the asset management system;

f) how well the organization is performing in meeting its objectives.

The specific awareness needs of any stakeholder should be determined by their role and its relationship to the organization meeting its asset management objectives. The need for awareness of some areas can apply to only a limited group of individuals, e.g. those directly involved in a particular function, such as plant maintenance.

7.3.1 The level of organizational awareness can be improved, for example, by the following:

a) a consultation process with staff throughout the organization concerning the establishment, operation, improvement and changes to the asset management system;

b) discussion of asset management in the organization’s newsletters, briefings, introduction programme or journals (including new employee orientation);

c) inclusion of asset management articles on relevant web pages;

d) inclusion of asset management as a topic in staff and management team meetings;
e) briefings for top management;

f) briefing key suppliers and distributors on the organization's asset management arrangements.

7.4 Communication

7.4.1 General

Asset management activities carried out by the organization should be communicated to relevant stakeholders periodically, in a coordinated way, as an integral part of the organization's asset management activity and asset management system.

7.4.2 Communication plan

The organization should develop communication plan(s) with consideration of:

a) building awareness of the asset management requirements and expectations;

b) developing an understanding of how the implementation of the asset management system can impact stakeholders;

c) promoting engagement with stakeholders to embrace transparency and create accountability for the asset management system;

d) managing, informing and influencing stakeholders who can directly impact the asset management plans and the achievement of the asset management objectives.

7.4.3 Communication plan content

The content of the communication plan(s) may include the following:

a) the benefits of implementing an activity, project, programme, or asset modification or augmentation, and how these improvements are expected to collectively or individually impact stakeholders and the organization;

b) any improvement schedules, including key milestones, who will be involved, and for how long;

c) any resource specific communications, including statements of the asset management system expectations;

d) the who, why, when and what of communicating, including how well the organization is performing against its organizational objectives and the contribution asset management is making to this performance;

e) if appropriate, what external and internal knowledge is needed for the stakeholders to make informed contributions or decisions, or provide informed feedback;

f) the representative who is best suited to deliver specific communications;

g) the format to be used for the communications;

h) the feedback and reporting processes.

7.5 Information requirements

7.5.1 The organization should determine the information needs related to its assets, asset management and its asset management system.

The organization should use a systematic approach to identify the necessary asset information and establish the appropriate information repositories. For example, the organization should undertake a
needs analysis, establish priorities, review system development options and data collection strategies, plan the creation of information repositories and data collection, then implement as appropriate.

NOTE ISO 55001 addresses information-related requirements in the following three subclauses:
— ISO 55001:2014, 7.5, which addresses the determination of required information;
— ISO 55001:2014, 7.6, which addresses the requirements for control over information;
— ISO 55001:2014, 9.1, which addresses the determination of requirements for information needed for performance reporting and evaluation.

7.5.2 In general, the organization should consider its asset information requirements related to the following areas:

a) strategy and planning (e.g. corporate service levels and objectives, asset strategy(ies), demand management strategy and plans);
b) process (e.g. process performance objectives and indicators, asset related processes and procedures);
c) technical and asset physical properties (e.g. asset attributes, ownership, design parameters, vendor information, physical location, condition, in service dates);
d) service delivery and operations (e.g. service levels, performance objectives, asset performance characteristics, future operational requirements, demand management objectives);
e) maintenance management (e.g. historical asset failures, betterment or replacement dates, future maintenance requirements);
f) performance management and reporting (e.g. asset performance data, continuous improvement objectives, regulatory reporting);
g) financial and resource management (e.g. historical cost, depreciation, asset replacement value, date of acquisition, materiality, capitalization rules, asset classification/hierarchies, life cycle costing analysis, useful lives of assets, residual value and any residual liabilities);
h) risk management;
i) contingency and continuity planning;
j) contract management (e.g. asset related contractual information, vendor information, service objectives, third party agreements).

7.5.3 When determining its information requirements the organization should consider:

a) the value of the information to enable decision making and its quality relative to the cost and complexity of collecting, processing, managing and sustaining the information;
b) the need to align its information requirements to suit the level of risk that an asset, or managing it, poses;
c) the participation of relevant stakeholders to determine the types of information required to support decision making as well as to ensure the completeness, accuracy and integrity of the necessary information;
d) the establishment and continual improvement of controls, specifications and level of accuracy for data;
e) the determination, assignment and periodic review of accountabilities for the stewardship of specific information;
f) the establishment of competences required to collect, interpret, utilize and report information;
g) the alignment of information requirements for different levels and functions within the organization: this includes the ability to have vertical alignment of the information from top management down into the operational areas, as well as horizontal alignment between asset management, financial management and risk management functions, by using a common terminology for financial and non-financial information;

h) the alignment of financial and non-financial terminology (it should be recognized that for some types of organizations, e.g. government type agencies, there are provisions that make their functional areas independently accountable for their own domain terminology: in such cases, a common terminology is unlikely to be achievable, however, conflicting terminology should be resolved where possible and documented);

i) the need for financial information regarding assets to be appropriate, consistent and traceable, and to reflect the technical and operational reality of the assets (e.g. completeness, accuracy, proper valuation and presentation, including ownership, is achieved through employing identifiable and auditable accounting records that are linked to the technical asset records);

j) the establishment of data collection processes from internal and external stakeholders (including contracted service providers);

k) the data flow and integration of information sources to planning, operational and reporting technology systems, appropriate for the size, complexity and capability of the organization (e.g. in more sophisticated asset management technology systems, specific data may be kept in separate asset registers);

l) its ability to maintain the appropriate quality and timeliness of the information (as the collection of data can be costly, the organization should prioritize data that is identified as strategically or operationally important).

7.6 Documented information

In establishing its documented information needs, the organization should consider the identification and definition of documented information that will be managed and maintained over the life cycle, taking into account its period of responsibility for the assets. The organization should also consider the requirement to maintain this documented information for any defined period beyond the disposal of the assets, in accordance with its business, legal and regulatory requirements. The controls put in place should be adequate for the type of information in supporting the asset management activity.

The organization should determine the documented information required to ensure effectiveness of its asset management system and asset management activity. Different types of documented information can address elements of the asset management system, asset management or a specific asset. The information required can differ from one organization to another and should be proportional to the complexity of the assets and the asset management activity.

When creating and updating documented information, an organization should determine if appropriate controls are in place to ensure that the information is appropriate; these controls are necessary to ensure that the personnel supporting the asset management activity are using the approved, accurate, most up to date information.

8 Operation

8.1 Operational planning and control

8.1.1 The organization should establish operational planning and control processes in order to support the effective delivery of the activities contained within the asset management plan(s). The processes should identify who is responsible for the planning and how the defined activities will be executed, including how risks arising during the planning and execution will be managed and controlled. (ISO 55001:2014,
Clause 8, defines the requirements for the operational planning and control of both asset management and the asset management system).

8.1.2 In implementing the processes and actions, the following criteria, amongst others, should be considered:

a) roles and responsibilities;

b) procedures;

c) resource allocation;

d) competency development.

8.1.3 Control mechanisms for the processes and actions can include elements such as the following:

a) process performance measures;

b) internal audit criteria and schedules.

The implementation of the processes and actions should produce documentation to enable verification that the process steps were followed as designed and the expected output of the process is achieved, e.g. this could include signed completed work orders.

8.1.4 The organization should implement those processes and actions needed to address its risks (see 6.2). This should be done by establishing the criteria for risk management processes, controlling implementation of these processes based on the defined criteria, and keeping documentation that demonstrates the risk management processes have been executed as planned.

The organization should have the capability to determine emerging risks and to consider their impacts on its asset management objectives. The asset management system should enable the organization to consider and plan changes that affect its assets or asset management with sufficient time to act if required.

Implementation should involve an iterative process to achieve a balance between cost, risk and performance, to resolve conflicts between what is planned and what can be achieved, while taking into account the constraints faced by the organization.

8.2 Management of change

8.2.1 Internal or external changes affecting assets, asset management or the asset management system can impact on the organization's ability to achieve its asset management objectives. These changes should be evaluated and mitigating actions should be taken prior to implementation. The organization should review the consequences associated with both planned and unplanned changes and take the necessary action to mitigate any foreseen adverse effects.

8.2.2 The organization's considerations should address changes that include, but are not limited to, the following:

a) organizational structures, roles or responsibilities;

b) asset management policy, objectives or plans;

c) process(es) or procedure(s) for asset management activities;

d) new assets, asset systems or technology (including obsolescence);

e) factors external to the organization (including new legal and regulatory requirements);

f) supply chain constraints;
g) demands for products and services, contractors or suppliers;

h) demands on resources, including competing demands.

8.2.3 The organization should have the capability to make evidence-based decisions on proposed changes and the ability to consider scenarios systematically across the entire organization.

Risks associated with a change should be considered in relation to their impact on asset management and the asset management system. This should include unintentional consequences that occur to other parts of the organization, as a result of a change, e.g. the impact of resource constraints due to changes in service delivery requirements.

8.3 Outsourcing

8.3.1 Outsourcing is a common method for an organization that prefers to perform certain asset management activities not by itself, but by an external or internal service provider. When these activities influence the achievement of the asset management objectives, these should be part of the asset management system, and should be documented.

8.3.2 The organization should formalize the relationship (e.g. through a contract, service level agreement or other appropriate commercial mechanism) for:

a) the governance of the outsourced activities, including responsibilities and authorities within the organization for managing the outsourced asset management processes and activities;

b) the processes and activities that are outsourced, with a description of the scope and boundaries, their interfaces with the organization and its control, quality, timelines, consultation requirements, financing, feedback and improvement opportunities;

c) the processes for the (bidirectional) exchange of information, knowledge, people, processes and technology at the start of the agreed period;

d) the processes for monitoring the activities of the assigned service provider(s);

e) the processes for sharing of knowledge, information and data, between the organization and its service provider(s);

f) the process of handing back the asset management activity from the service provider(s), including the required state of the asset and associated information.

8.3.3 Any asset management objectives, processes and activities that are outsourced should be controlled by the organization to provide assurance that performance is as planned. The performance of outsourced activities should be subject to a regular management reviews to ensure that they are adequately controlled.

The more extensively an organization chooses to outsource the delivery of its asset management, the greater will be the degree of control and integration into the asset management system that it will need to exert over the service provider(s), in order to give assurance that delivery of the SAMP will be achieved. The extent of outsourcing could require a service provider to establish its own asset management system that is aligned with the organization’s asset management objectives.

8.3.4 The organization should consider the ownership and protection of intellectual property and corporate knowledge (including that generated during the outsourcing) when outsourcing asset management activities.

When outsourcing any life cycle activities and asset management activities, the organization should consider the risks and impacts on its assets, asset management and asset management system.
The organization should consider what potential risks cannot be transferred, even if the related asset management activities are transferred (e.g. damage to its reputation). A corresponding control over those risks should be maintained within the organization.

9 Performance evaluation

9.1 Monitoring, measurement, analysis and evaluation

9.1.1 General

9.1.1.1 The organization should develop processes to provide for the systematic measurement, monitoring, analysis and evaluation of the organization’s assets, asset management system and asset management activity on a regular basis. In the development of these processes (and any associated procedures) the following should be taken into account:

a) setting of performance metrics and associated indicators, e.g. condition or capacity indicators;

b) confirmation of compliance with the requirements;

c) examination of historical evidence;

d) the use of documented information to facilitate subsequent corrective actions and decision making.

9.1.1.2 The processes should also reference the asset management policy and objectives.

More specifically the processes for monitoring performance should address:

a) the setting of performance metrics, including qualitative and quantitative measurements (financial and non-financial) that are appropriate to the needs of the organization;

b) the extent to which the organization’s asset management policy and objectives are met;

c) the evaluation of compliance with legal and regulatory requirements, and any other requirements to which the organization subscribes;

d) identifying when the monitoring and measuring should take place;

e) the ability to aggregate and report information to those accountable for the asset management system and asset activities (see 7.5, bullet g));

f) the quality, reliability and completeness of the financial and non-financial asset information;

g) enabling top management to make statements on the organization's ability to manage its assets (see 4.2);

h) the performance of activities outsourced to external providers;

i) assessing the performance of the asset management processes, procedures and functions;

j) proactive indicators that are related to performance of the assets, asset management system, and activities (e.g. capacity or condition indicators);

k) reactive measures of performance to monitor failures, incidents, non-conformities (including near misses and false alarms) and other historical evidence of deficient asset management system and activity performance;

l) recording the data and results of monitoring and measurement, sufficient to facilitate subsequent corrective action analysis.
9.1.1.3 A set of performance indicators should be developed to measure the asset management activity and its outcomes. Measurements can be either quantitative or qualitative, financial and non-financial. Indicators should provide useful information to determine both successes and areas requiring corrective action or improvement. The organization should consider the relationship and alignment between performance indicators.

9.1.1.4 The asset management system should employ data from monitoring and measurement to identify patterns and obtain information regarding its performance. These data should be used to evaluate whether the organization’s policy and objectives are being achieved, as well as identifying corrective actions and areas for improvement.

Documented information on all periodic evaluations and their results should be maintained.

The organization should analyse and, at planned intervals, evaluate the outcomes from the monitoring and measurement.

The performance of activities outsourced to external service providers should be monitored and be based on the evaluation of reported results, audits performed by the organization, or independent auditor’s reports.

9.1.2 Evaluation of the performance of the asset portfolio and asset management processes

9.1.2.1 The organization should conduct evaluations of its assets and asset management activity in order to ensure their continuing suitability, adequacy and effectiveness.

The evaluations should address the possible need for changes to policy, objectives, strategies, and other elements of the asset management system, e.g. in the light of reviews, changing circumstances, the commitment to continual improvement.

Evaluations can take the form of internal or external audits, or self-assessments. The frequency and timing of evaluations should be determined by the organization or can be determined by laws and regulations, depending on the size, nature and legal status of the organization. When setting the frequency of condition or performance monitoring and the parameters for measurement, the organization should consider, at a minimum, the costs of monitoring, the risks of failure or nonconformity, and potential deterioration mechanisms and deterioration rates. They might also be influenced by the requirements of stakeholders.

9.1.2.2 An evaluation of the organization’s assets and asset management activity should verify whether:

a) the organization’s asset management policy, strategies, objectives and asset management processes accurately reflect its priorities and requirements (i.e. the organizational objectives);

b) the persons doing work under the control of the organization are competent;

c) its procedures are effective and up-to-date;

d) processes have been clearly defined, documented and effectively implemented and complied with;

e) there are processes for on-going training and awareness;

f) the organization’s assets and asset management fulfil their required function;

g) the organization’s asset management is appropriate to the level of risk faced by the organization;

h) the asset management plan(s) and processes have been effectively communicated to relevant stakeholders;

i) persons doing work under the organization’s control understand their roles and responsibilities;

j) change control processes are in place and operate effectively;
k) any changes (internal or external) that impact the organization are reviewed in relation to the asset management activities.

9.1.2.3 Outcomes from the evaluation should include evidence of whether:

a) there is proactive management and governance of the organization's asset management;

b) people are trained and competent;

c) there is operational planning and control of asset management;

d) the organization's asset management activities are in compliance with its processes;

e) significant changes in the organization have been reflected in the organization's asset management processes in a timely manner.

Documented information relating to all periodic evaluations and their results should be maintained as evidence.

9.1.2.4 In the context of continual improvement, the organization can acquire knowledge on new asset management technology and practices, including new tools and techniques (e.g. development of reliability and predictive technologies during the procurement of new assets or the design of modified assets). This should be evaluated to establish its potential benefit to the organization.

9.1.2.5 To ensure that reported information used for monitoring has the same meaning with respect to different functions in the organization, common financial and non-financial terminology should be used in reports. Because cost plays such an important role in reflecting asset related performance, it may be useful to have a shared set of classification systems, hierarchical structures, and a common understanding of how asset portfolios, asset systems and individual assets are broken down for life cycle management purposes.

The change in future value of the assets and the risk profile should be evaluated in both a financial context and a non-financial context. The evaluation team should include stakeholders from relevant disciplines.

9.1.2.6 Monitoring should ensure that there is consistency and traceability between technical asset information and accounting records. In addition, monitoring should address the following key aspects of the data registration process.

a) a uniform technical, operational and financial glossary;

b) a technical, operational and financial linkage, which is consistent and traceable to the assets and their components at a predefined level of detail;

c) adequate and accurate financial and non-financial data and information of technical and operational events that have a potential impact on financial reporting.

This monitoring in the financial reporting system should be done at a level suitable to the risk, complexity and value of the assets. An asset breakdown structure can be used to identify the individual components of an asset, to enable the organization to take into account the significance of the value of the components in relation to the asset, and to determine the differences between the technical and economic lives of the components.
9.2 Internal audit

9.2.1 The organization should conduct internal audits at planned intervals to ensure the asset management system conforms to its requirements (and to the requirements of ISO 55001).

It is essential to conduct internal audits of the asset management system, particularly in relation to critical assets and asset systems, to ensure that the asset management system is achieving its objectives and plans and is identifying opportunities for improvement. Internal audits of the asset management system should be conducted at planned intervals to determine and provide information to top management on the appropriateness and effectiveness of the asset management system, as well as to provide the basis for setting objectives for continual improvement.

9.2.2 The organization should establish an audit process to direct the planning and conduct of audits, and to determine the audits needed to meet its objectives. The process should be based on the organization’s activities, its risk assessments, the results of past audits, and other relevant factors.

Internal audits should be based on the full scope of the asset management system, however, it is not necessary for each audit to cover the entire system. Audits may be divided into smaller parts provided the audit programme ensures that all organizational units, functions, activities and system elements and the full scope of the asset management system are audited within the auditing period designated by the organization. In deciding the scope of an audit, it is good practice to consider the risk associated with both the asset management system and the assets. This can aid the relevance of an audit and help to objectively reassess the risk areas.

The results of an internal audit of an asset management system can be used to correct or prevent specific nonconformities, as an input for continual improvement, and to provide input for management review.

Internal audits of the asset management system may be performed by personnel from within the organization or by external persons selected by the organization, working on its behalf. In either case, the persons conducting the audit should be competent and in a position to do so impartially and objectively. In smaller organizations, auditor independence can be demonstrated by an auditor being free from responsibility for the activity being audited.

Audits should support learning and improvement of the asset management system. To achieve this, the audits should focus on the performance of the asset management processes, as opposed to the performance of persons within the processes. Attention should be paid to examples of good practice and improvement opportunities. At the same time, audits should also determine system deficiencies, by checking conformity of practice and the asset management system with each other and to the requirements of ISO 55001.

9.2.3 Self-assessment can be helpful in driving continual improvement. Self-assessments should evaluate the viability and suitability of the asset management policy, objectives and plans to ensure they are consistent with each other, suitable, adequate, and achievable. This requires assessment of the following:

a) assumptions related to the organization’s asset management;

b) the organization’s process(es) and procedure(s), methods, tools and techniques;

c) the availability and allocation of funds and resources.

The self-assessment process should encourage participants to identify opportunities for continual improvement. Active participation, understanding and support of the organization’s employees are important in conducting a self-assessment review.
9.3 Management review

9.3.1 Top management should review the organization’s assets, asset management system and asset management activity, as well as the operation of its policy, objectives and plans, at planned intervals, to ensure their suitability, adequacy and effectiveness.

The review should also consider whether the asset management policy continues to be appropriate for the organization’s purpose. It should establish new or updated asset management objectives for continual improvement, appropriate to the coming period, and consider whether changes are needed to any elements of the assets, asset management processes and the asset management system.

9.3.2 Inputs to management reviews should include:

a) the status of actions from previous management reviews;

b) changes in external and internal issues that are relevant to the asset management system, including changing circumstances (including developments in legal, regulatory and other requirements related to asset management), changes in technology, and changes in market requirements;

c) information on the asset management performance, including trends in:

   1) nonconformities and corrective actions, including evaluations of performance in addressing incident investigations, corrective actions and preventive actions;

   2) monitoring and measurement results including:

      i) the results of communication, participation and consultation with employees and other stakeholders (including complaints);

      ii) the performance of the assets, asset management processes and the asset management system, including trends apparent from nonconformities and corrective actions, the results of monitoring and measurement, and audit findings;

      iii) the results of other evaluations of the assets or asset management system, e.g. condition or capacity;

      iv) evaluations of compliance with applicable legal and regulatory requirements and with other requirements to which the organization subscribes;

      v) audit results;

d) asset management activities;

e) opportunities for continual improvement;

f) changes in the profile of risks and opportunities;

g) asset performance and condition.

9.3.3 Management reviews provide top management with an opportunity to evaluate the continuing suitability, adequacy and effectiveness of the assets, asset management, and asset management system. The management review should cover the scope of the asset management system and the asset management activity, although it is not necessary to review all elements at once and the review process may take place over a period of time.

Reviews of the implementation and outcomes by top management should be regularly scheduled and evaluated. While ongoing system reviews are advisable, formal reviews should be structured and appropriately documented and scheduled on a suitable basis. Persons who are involved in implementing the asset management system and allocating its resources should be involved in the management reviews.
9.3.4 The outputs from management reviews should include decisions and actions relating to improvements in asset management system and activity including:

a) variations to the scope, policy and objectives;
b) criteria for asset management decision making;
c) updates to performance requirements;
d) resources including financial, human and physical resources;
e) changes to controls and how their effectiveness is measured, including roles, responsibilities and authorities.

9.3.5 The organization should retain documented information as evidence of the results of management reviews and should communicate the results of management reviews to relevant stakeholders. It should also take appropriate action based on the results, while managing any changes (see 8.2).

Management reviews should also cover aspects of the asset management system and activities, if any, that are outsourced to external service providers. Relevant information from management reviews should be communicated to specific employees, external service providers or other stakeholders.

Relevant outputs from management reviews should be used by top management during reviews of the organizational plan.

10 Improvement

10.1 Nonconformity and corrective action

10.1.1 General

The organization should be aware that nonconformities (including failures) can occur in its assets, asset management activity and asset management system. The organization should establish plans and processes to control nonconformities and their associated consequences, to minimize any adverse effects on the organization and on stakeholder needs and expectations. This can be accomplished by documenting and reviewing past nonconformities, evaluating how the consequences were dealt with, and by determining methodologies to prevent future nonconformity.

Corrective actions are actions taken to address the root cause(s) of identified non-conformances, or incidents, in order to manage their consequences, and to prevent or reduce the likelihood of recurrence. Aspects to be considered in establishing and maintaining corrective action processes should include:

a) the identification and execution of corrective measures, both for the short term and the long term;
b) the evaluation of any impact on risk identification and assessment results, including any need to update risk identification, assessment and control report(s);
c) the recording of any required changes in processes or procedures resulting from the corrective action or risk identification, assessment and control, and execution of these changes.

10.1.2 Processes for the investigation of asset-related nonconformities and incidents

The organization should establish, implement and maintain process(es) (and their associated procedure(s)) for the handling and investigation of nonconformities, functional failures, and incidents associated with assets, asset systems and the asset management system. These process(es) should define the significant criteria for the investigation of non-conformities or incidents and the necessary responsibilities and authorities (for all the actions listed in ISO 55001:2014, 10.1).
10.1.3 Processes for implementing corrective actions

The organization should establish, implement and maintain process(es) for instigating corrective action(s) for eliminating the causes of nonconformities or incidents identified from investigations, evaluations of compliance and audits, to avoid their recurrence.

Any corrective actions taken and their timings should be commensurate with the risk(s) encountered. Where a corrective action identifies new or changed risks, or the need for new or changed process(es), procedure(s) or other arrangements to control life cycle activities, the proposed actions should be risk assessed prior to implementation (see 8.2).

The organization should monitor the timely close-out or completion and the effectiveness of the corrective action(s). Documented information should be kept on the corrective actions taken.

The organization should ensure that any necessary changes arising from corrective actions are made to the asset management system (see 8.2).

10.2 Preventive action

Preventive actions, which may include predictive actions, are those taken to address the root cause(s) of potential failures or incidents, as a proactive measure, before such incidents occur. The organization should establish, implement and maintain process(es) for initiating preventive or predictive action(s).

Elements to be considered in establishing and maintaining preventive action processes include:

a) the use of appropriate sources of information;
b) the identification of any potential failures;
c) the use of an appropriate methodology;
d) the initiation and implementation of preventive action;
e) the recording of any changes in processes and procedures resulting from the preventive action;
f) assessment of the preventive action;
g) the input to the asset management plan(s) from preventive actions;
h) the need to keep documented information on the preventive or predictive actions.

10.3 Continual improvement

10.3.1 Opportunities for improvement should be identified, assessed and implemented across the organization as appropriate, through a combination of monitoring and corrective actions for the assets, asset management, or asset management system. Continual improvement should be regarded as an ongoing iterative activity, with the ultimate aim of delivering the organizational objectives. It should not be interpreted as cyclic (e.g. annual) improvement in asset performance parameters just because they can be achieved.

10.3.2 Continual improvement can be organized as a top-down or bottom-up process, or as a combination. The organization should establish, implement and maintain process(es) for determining opportunities and assessing, prioritizing and implementing actions to achieve continual improvement and reviewing their subsequent effectiveness. These processes may include:

a) non-conformity and corrective action (see 10.1), in particular failure and incident investigation (see 10.1.2);
b) preventive action (see 10.2);
c) trends in performance (see 9.1);
d) evaluation of compliance (see 9.1.1);
e) internal and external audits (see 9.2);
f) management review (see 9.3);
g) stimulating employees to come forward with suggestions;
h) management of change (see 8.2).

10.3.3 The organization should actively seek and acquire knowledge about new asset management-related technology and practices, including new tools and techniques; these should be evaluated to establish their potential benefit to the organization and be incorporated into the asset management system as appropriate. Examples include:

a) active participation in professional bodies and industry associations;
b) conferences, seminars, publications, (online) forums, journals;
c) benchmarking and technology transfer initiatives, and competitor check-ups;
d) engaging specialist organizations;
e) research and development;
f) consultation of suppliers and clients.

10.3.4 Although the opportunities for improvement can be widely different in size and effect, the approach for processing them may consist of the following steps:

a) identification of improvement needs and potential;
b) evaluation of options;
c) estimation and determination of financial and non-financial consequences;
d) risk assessment and management of change (see 8.2) aspects;
e) links with decision-making criteria (see 4.2);
f) selection and execution;
g) tracking of outcomes and review.
Annex A
(informative)

Information on asset management activities

Relevant asset management subject areas addressed by other published international, regional, or national standards include, but are not limited to, the following:

- data management;
- condition monitoring;
- risk management;
- quality management;
- environmental management;
- systems and software engineering;
- life cycle costing;
- dependability (availability, reliability, maintainability, maintenance support);
- configuration management;
- tero-technology;
- sustainable development;
- inspection;
- non-destructive testing;
- pressure equipment;
- financial management;
- value management;
- shock and vibration;
- acoustics;
- qualification and assessment of personnel;
- project management;
- property and property management;
- facilities management;
- equipment management;
- commissioning process;
- energy management.

Users of ISO 55000, ISO 55001 and this International Standard should also refer to such standards wherever possible, to ensure consistent delivery of asset management throughout their organization.
Annex B
(informative)

Relationship between key elements of an asset management system

Figure B.1 shows the relationship between the key elements of an asset management system, together with the related clauses in ISO 55001.

NOTE 1 Only the primary connections are shown to avoid over complexity.

NOTE 2 This does not aim to repeat the distinction between asset management and an asset management system: it is a connections view showing directions of influence.

NOTE 3 The grey highlighted box designates the boundary of the asset management system.
Bibliography

[1] ISO 9000, Quality management systems — Fundamentals and vocabulary
[2] ISO 9001, Quality management systems — Requirements
[4] ISO 14001, Environmental management systems — Requirements with guidance for use
[8] ISO 17359, Condition monitoring and diagnostics of machines — General guidelines
[9] ISO 19011, Guidelines for auditing management systems
[10] ISO 20815, Petroleum, petrochemical and natural gas industries — Production assurance and reliability management
[12] ISO 22301, Societal security — Business continuity management systems — Requirements
[14] ISO 37500, Guidance on outsourcing
[16] ISO/IEC 15288, Systems and software engineering — System life cycle processes
[18] IEC 31010, Risk management — Risk assessment techniques
[21] ASTM E2132, Standard Practice for Inventory Verification: Electronic and Physical Inventory of Assets
[23] ASTM E 2608, Standard Practice for Equipment Control Matrix (ECM)

1) Under preparation.


RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 31:
Reference(s): Exhibit 2B, Section D2, p. 44, Figure 26, Figure 27

a) Please identify the one station in Figure 26 that is forecast to be near capacity in 2020 and provide the forecast date it will be at capacity.

RESPONSE:

a) Manby TS is forecasted to be at 95% capacity in 2020 and 100% in 2023.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 32:
Reference(s): Exhibit 2B, Section D3, p. 4, Table 1

For each Planned Maintenance Activity:

a) Provide the OEB’s Minimum Requirements.

b) Identify changes in the cycle from EB-2014-0116.

c) For each change in part b) please provide an explanation and the expected outcome of the change.

RESPONSE:

a) Please see Table 1 below for the OEB Minimum Inspection Requirements\(^1\).

\(^1\) OEB Minimum Inspection Requirements under Appendix C of the Distribution System Code.
<table>
<thead>
<tr>
<th>System</th>
<th>Asset Class/Type</th>
<th>Planned Maintenance Activities</th>
<th>Toronto Hydro Cycle</th>
<th>OEB Minimum Inspection Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overhead</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pole-top Transformer</strong></td>
<td>Line Patrols</td>
<td>3 Years Visual, 1 Year Infrared</td>
<td>3 Years</td>
<td></td>
</tr>
<tr>
<td><strong>Distribution Poles</strong></td>
<td>Line Patrols</td>
<td>3 Years Visual</td>
<td>3 Years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wood Pole Inspection &amp; Treatment</td>
<td>10 Years</td>
<td>N/A</td>
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<tr>
<td><strong>Primary Conductors</strong></td>
<td>Line Patrols</td>
<td>3 Years Visual, 1 Year Infrared</td>
<td>3 Years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tree Trimming</td>
<td>1-5 Years, with the majority being 2-3 Years</td>
<td>N/A</td>
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<tr>
<td><strong>Secondary Conductors</strong></td>
<td>Line Patrols</td>
<td>3 Years Visual</td>
<td>3 Years</td>
<td></td>
</tr>
<tr>
<td><strong>Switches</strong></td>
<td></td>
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<tr>
<td></td>
<td>Line Patrols</td>
<td>3 Years Visual, 1 Year Infrared</td>
<td>3 Years</td>
<td></td>
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<tr>
<td></td>
<td>Maintenance (SCADA-Mate &amp; Gang-Operated)</td>
<td>4 Years</td>
<td>N/A</td>
<td></td>
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<tr>
<td></td>
<td>Battery Replacement for switches (SCADA-Mate &amp; Gang-Operated) and Repeater Radio</td>
<td>3 Years</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>Insulators</strong></td>
<td>Insulator Washing (for Porcelain)</td>
<td>6 Months</td>
<td>N/A</td>
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<tr>
<td><strong>Underground</strong></td>
<td>Padmounted Transformer</td>
<td>Inspection (Civil + Electrical)</td>
<td>3 Years</td>
<td>3 Years</td>
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<tr>
<td><strong>Submersible Transformer</strong></td>
<td>Vault Inspection (Civil + Electrical)</td>
<td>3 Years</td>
<td>3 Years</td>
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<tr>
<td><strong>CRD Transformer</strong></td>
<td>Insulation (Civil + Electrical)</td>
<td>3 Years</td>
<td>3 Years</td>
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<tr>
<td><strong>URD Transformer</strong></td>
<td>Inspection (Civil + Electrical)</td>
<td>1 Year</td>
<td>3 Years</td>
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<tr>
<td><strong>Building Vault Transformer</strong></td>
<td>Inspection (Civil + Electrical)</td>
<td>3 Years</td>
<td>3 Years</td>
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<tr>
<td><strong>Padmounted Switch</strong></td>
<td>Inspection (Civil + Electrical)</td>
<td>1 Year</td>
<td>3 Years</td>
<td></td>
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<td></td>
<td>Battery Replacement</td>
<td>3 Years</td>
<td>N/A</td>
<td></td>
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<tr>
<td><strong>Cable Chamber</strong></td>
<td>Cable Chamber</td>
<td>10 Years</td>
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<tr>
<td><strong>Cables</strong></td>
<td>Contact Voltage Scanning</td>
<td>1 Year</td>
<td>N/A</td>
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</table>

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>System</th>
<th>Asset Class/Type</th>
<th>Planned Maintenance Activities</th>
<th>Toronto Hydro Cycle</th>
<th>OEB Minimum Inspection Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network</strong></td>
<td>Network Transformer</td>
<td>Network Vault Inspection - Electrical</td>
<td>1 Year</td>
<td>3 Years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network Vault Inspection - Civil</td>
<td>6 Months</td>
<td>3 Years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reverse Power Breaker Overhaul</td>
<td>3 Years</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protector Top Cleaning</td>
<td>1 Year</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network Protector Overhaul – High Voltage</td>
<td>4 Years</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network Protector Overhaul – Low Voltage</td>
<td>5 Years</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Station</strong></td>
<td>Station TS &amp; MS Facilities</td>
<td>Monthly Inspections</td>
<td>1 Month</td>
<td>1 Month</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seasonal Detailed Inspection</td>
<td>6 Months</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Circuit Breaker (All Types) &amp; Switch</td>
<td>Maintenance</td>
<td>4 Years</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bus Disconnect Switches</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>B-Bus</td>
<td>B-Bus Cleaning</td>
<td>4 Years</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Power Transformer</td>
<td>Equipment Maintenance</td>
<td>4 Years</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>DC Battery &amp; Charger</td>
<td>Seasonal Detailed Inspection</td>
<td>6 Months</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Compressed Air System</td>
<td>Station Compressed Air System Maintenance</td>
<td>6 Months</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Station Alarms in Downtown</td>
<td>Alarm Testing</td>
<td>1 Year</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Pilot Wire</td>
<td>Pilot Wire Protection</td>
<td>6 Years</td>
<td>N/A</td>
</tr>
</tbody>
</table>
b) Toronto Hydro’s cycles for each planned maintenance activity in Table 1 have not changed from the cycles that were specified in EB-2014-0116.

c) No planned maintenance activity has had a change in cycles as per part (b).
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 33:

Reference(s): Exhibit 2B, Section D3, p. 8, Figure 1

a) For each of the years 2015 to 2018, please provide the number of deficiencies per year from Preventative & Predictive Maintenance; Field Operations & Customer Communications; and Emergency Response.

RESPONSE:

a) Please see Toronto Hydro’s response to interrogatory 4A-AMPCO-81 for Corrective Maintenance and 2B-AMPCO-61 for Reactive Capital.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 34:
Reference(s): Exhibit 2B, Section D3, p. 9, Figure 1

THES indicates work requests are classified into P1 (15 days to resolve), P2 (60 days to resolve) and P3 (180 days to resolve).

a) How does THESL track completion of these work requests?

b) Please provide the accomplishment rate of work requests for 2015 to 2018.

c) How does THESL use this data in its ACA?

RESPONSE:

a) Toronto Hydro tracks work requests from the time a work request is issued to a crew to the return of documentation demonstrating that corrective action, if required, has been completed.

b) Table 1 below includes the number of Reactive Capital and Corrective Maintenance work requests created from 2015 to 2017 and the number of work requests closed in their respective years. Please note that year-end 2018 results are not available at this time.
Table 1: Work Requests Accomplishment Rate from 2015 – 2017

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Requests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Created</td>
<td>6,494</td>
<td>7,134</td>
<td>8,347</td>
<td>21,975</td>
</tr>
<tr>
<td>Work Requests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed</td>
<td>5,998</td>
<td>6,386</td>
<td>7,823</td>
<td>20,207</td>
</tr>
<tr>
<td>Accomplishment Rate</td>
<td>92%</td>
<td>90%</td>
<td>94%</td>
<td>92%</td>
</tr>
</tbody>
</table>

c) The work request prioritization process and the ACA rely on the same inspection and maintenance data as an input. Reactive and corrective work requests trigger short-term asset interventions to mitigate risks, while ACA results inform system investment planning decisions and project prioritization activities.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO INTERROGATORIES

INTERROGATORY 35:

Reference(s): Exhibit 2B, Section D3, p. 9

Please complete the attached excel spreadsheet.

RESPONSE:

Please see the Excel spreadsheet entitled “2B-AMPCO-35.xlsx”. Toronto Hydro does not currently have reliability results finalized for 2018.
### Asset Failures by Asset Type

Ref: 2B Section D2

<table>
<thead>
<tr>
<th>Asset Type</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overhead</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pole Transformer</td>
<td>185</td>
<td>198</td>
<td>231</td>
<td>113</td>
<td>117</td>
<td>54</td>
</tr>
<tr>
<td>Wood Poles</td>
<td>131</td>
<td>195</td>
<td>236</td>
<td>135</td>
<td>159</td>
<td>104</td>
</tr>
<tr>
<td><strong>Auxiliary Equipment</strong></td>
<td></td>
<td>235</td>
<td>290</td>
<td>267</td>
<td>242</td>
<td>214</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Underground</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U/G Cable</td>
<td>177</td>
<td>144</td>
<td>134</td>
<td>163</td>
<td>102</td>
<td>118</td>
</tr>
<tr>
<td>Submersible Transformers</td>
<td>113</td>
<td>132</td>
<td>140</td>
<td>361</td>
<td>213</td>
<td>89</td>
</tr>
<tr>
<td>Pad Mounted Transformers</td>
<td>42</td>
<td>49</td>
<td>62</td>
<td>39</td>
<td>80</td>
<td>36</td>
</tr>
<tr>
<td>U/G Switches</td>
<td>77</td>
<td>62</td>
<td>123</td>
<td>92</td>
<td>119</td>
<td>100</td>
</tr>
<tr>
<td>Cable Chambers</td>
<td>15</td>
<td>26</td>
<td>28</td>
<td>21</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td><strong>U/G Primary Cable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>U/G Secondary Cable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Transformer</td>
<td>28</td>
<td>43</td>
<td>58</td>
<td>45</td>
<td>62</td>
<td>40</td>
</tr>
<tr>
<td>Network Protector</td>
<td>16</td>
<td>77</td>
<td>93</td>
<td>100</td>
<td>123</td>
<td>165</td>
</tr>
<tr>
<td><strong>Power Transformer</strong></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>KSO Circuit Breaker*</td>
<td>17</td>
<td>25</td>
<td>29</td>
<td>18</td>
<td>39</td>
<td>60</td>
</tr>
<tr>
<td>DC Battery System</td>
<td>4</td>
<td>4</td>
<td></td>
<td>24</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td><strong>Energy Meter</strong></td>
<td>3114</td>
<td>5939</td>
<td>4362</td>
<td>5326</td>
<td>5234</td>
<td>6708</td>
</tr>
<tr>
<td>Instrument Transformer</td>
<td>28</td>
<td>49</td>
<td>17</td>
<td>20</td>
<td>23</td>
<td>42</td>
</tr>
</tbody>
</table>

*Asset failures reported for all breakers. Information to segregate out failures for only KSO not available for the period requested.*
2B-AMPCO-35  
Ref: 2B Section D3 P9

1 Allocation of Work Requests

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overhead Assets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>673</td>
<td>333</td>
<td>422</td>
<td>347</td>
</tr>
<tr>
<td>P2</td>
<td>421</td>
<td>452</td>
<td>316</td>
<td>434</td>
</tr>
<tr>
<td>P3</td>
<td>52</td>
<td>218</td>
<td>107</td>
<td>105</td>
</tr>
<tr>
<td><strong>Underground Assets</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>1079</td>
<td>948</td>
<td>1175</td>
<td>897</td>
</tr>
<tr>
<td>P2</td>
<td>1099</td>
<td>726</td>
<td>1117</td>
<td>1033</td>
</tr>
<tr>
<td>P3</td>
<td>1354</td>
<td>2485</td>
<td>3096</td>
<td>1943</td>
</tr>
<tr>
<td><strong>Network Assets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>198</td>
<td>130</td>
<td>270</td>
<td>241</td>
</tr>
<tr>
<td>P2</td>
<td>272</td>
<td>120</td>
<td>323</td>
<td>544</td>
</tr>
<tr>
<td>P3</td>
<td>507</td>
<td>885</td>
<td>688</td>
<td>693</td>
</tr>
<tr>
<td><strong>Station Assets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>334</td>
<td>293</td>
<td>260</td>
<td>228</td>
</tr>
<tr>
<td>P2</td>
<td>255</td>
<td>220</td>
<td>320</td>
<td>451</td>
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<td>P3</td>
<td>105</td>
<td>256</td>
<td>98</td>
<td>165</td>
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<tr>
<td><strong>Other</strong></td>
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</tr>
<tr>
<td>P1</td>
<td></td>
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</tr>
<tr>
<td>P2</td>
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<td></td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All Work Requests included in above.

2 Allocation of Work Requests to System Renewal Investments

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E6.2 Underground - Horseshoe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Work Requests are not issued and addressed by these programs. Work Requests are issued and addressed through the Reactive &amp; Corrective Capital program (Exhibit 2B, Section E6.7) or the Corrective Maintenance program (Exhibit 4A, Tab 2, Schedule 4).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E6.3 Underground - Downtown</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>P2</td>
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</tr>
<tr>
<td>P3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E6.4 Network System</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
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</tr>
<tr>
<td>P2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Outages (Customer Interruptions) Caused by Asset Failure
Ref: 2B Section E6.3

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground - Horseshoe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>177,361</td>
<td>144,783</td>
<td>175,653</td>
<td>152,228</td>
<td>136,110</td>
</tr>
<tr>
<td>Transformers</td>
<td>11,971</td>
<td>14,171</td>
<td>18,313</td>
<td>29,120</td>
<td>41,280</td>
</tr>
<tr>
<td>Switches</td>
<td>10,455</td>
<td>40,308</td>
<td>31,136</td>
<td>27,549</td>
<td>11,718</td>
</tr>
</tbody>
</table>

# Outage Minutes (Customer Interruption Minutes) Caused by Asset Failure

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground - Horseshoe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>7,839,052</td>
<td>6,991,906</td>
<td>8,115,982</td>
<td>8,301,388</td>
<td>6,237,826</td>
</tr>
<tr>
<td>Transformers</td>
<td>1,231,785</td>
<td>1,091,128</td>
<td>1,201,478</td>
<td>1,186,042</td>
<td>1,659,620</td>
</tr>
<tr>
<td>Switches</td>
<td>344,049</td>
<td>1,744,208</td>
<td>1,490,970</td>
<td>1,213,101</td>
<td>1,412,014</td>
</tr>
</tbody>
</table>

# Outages (Customer Interruptions) Caused by Asset Failure
Ref: 2B Section E6.3

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground - Horseshoe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please see table above.

# Outage Minutes (Customer Interruption Minutes) Caused by Asset Failure

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground - Horseshoe</td>
<td></td>
<td></td>
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<tr>
<td>Cables</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
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</tr>
<tr>
<td>Switches</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Please see table above.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO INTERROGATORIES

INTERROGATORY 36:

Reference(s): Exhibit 2B, Section D3, p. 10

THESL does not anticipate a decline in corrective maintenance, emergency maintenance, or reactive capital in the forecast period.

Does THESL anticipate a decline in preventative maintenance or predictive maintenance? Please explain.

RESPONSE:

Toronto Hydro does not anticipate a decline in overall Preventative and Predictive Maintenance expenditures during the 2020-2024 period. For a description of the expenditure drivers and variances in the Preventative and Predictive Maintenance programs for the 2015-2020 period, please refer to Exhibit 4A, Tab 2, Schedules 1-3.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 37:
Reference(s): Exhibit 2B, Section D3, pp. 13-19

a) For each of the asset categories in Tables 2, 3,4,5 and 6, please advise of any changes in Asset Replacement Practices since 2014.

b) Please provide the number of poles replaced on an individual basis by pole type for each of the years 2013 to 2018 and forecast for each of the years 2019 to 2024.

c) Please provide the number of poles replaced as part of area rebuilds for each of the years 2013 to 2018 and forecast for each of the years 2019 to 2024.

RESPONSE:
a) Changes in asset replacement practices since 2014 are specified in Table 1 below:

Table 1: Changes in Asset Management Practices

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Changes in Asset Replacement Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Pole-top Transformers</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td>Toronto Hydro expects to complete its dedicated Polymer SMD-20 Switch Renewal and SCADA-Mate R1 Switch Renewal programs in</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>Asset Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Conductor</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Underground Cables (Polyethylene)</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Underground Cables (Lead)</td>
<td>Please refer to Exhibit 2B, Section D3.1.2, Table 3, Page 14 under the “Underground Cables (Lead)” section.</td>
</tr>
<tr>
<td>Underground Switches</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Cable Chambers</td>
<td>Please refer to Exhibit 2B, Section D3.1.2, Table 3, Page 15 under the “Cable Chambers” section.</td>
</tr>
<tr>
<td>Underground Residential Distribution (URD)</td>
<td>Previously, Toronto Hydro’s proactive replacement activities within the URD system were limited to submersible vintage URD switches which possessed inherent design flaws and needed to be replaced. As noted in Section 2B, Section E6.3.1, Page 3, Line 20, Toronto Hydro has seen a sharp increase in the volume of corrective work requests on this system, along with an increase in outage frequency and an observed deterioration in condition. As a result, beginning in this 2020-2024 application Toronto Hydro will be proactively rebuilding switching and non-switching vaults and replacing switches and transformers respectively.</td>
</tr>
<tr>
<td>Network Automatic Transfer Switches (“ATS”) and Reverse Power Breakers (“RPB”)</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
<tr>
<td>Network Units</td>
<td>No changes in asset replacement practices since 2014.</td>
</tr>
</tbody>
</table>
Network Vaults | No changes in asset replacement practices since 2014.
--- | ---
Network Cables | Please refer to “Underground Cables (Polyethylene)” and “Underground Cables (Lead)” above.
Transformer Station (“TS”) Switchgear | No changes in asset replacement practices since 2014.
TS Oil Circuit Breakers (KSO) | No changes in asset replacement practices since 2014.
Municipal Station (“MS”) Switchgear | No changes in asset replacement practices since 2014.
MS Primary Supply | Please refer to Exhibit 2B, Section D3.1.2, Table 5, Page 18 under the “MS Primary Supply” section.
Power Transformers | No changes in asset replacement practices since 2014.
Station Service Transformers (“SSTs”) | No changes in asset replacement practices since 2014.
Remote Terminal Units (“RTUs”) | No changes in asset replacement practices since 2014.
Pilot-wire Relays & Copper Communication Cable | No changes in asset replacement practices since 2014.
Direct Current (“DC”) Battery Systems | No changes in asset replacement practices since 2014.
Meters | No changes in asset replacement practices since 2014.

b) Please refer to Toronto Hydro’s response to interrogatory 4A-AMPCO-76 for the poles replaced reactively (i.e. on an individual basis) each year between 2013 and 2018.

Between 2019 and 2024, Toronto Hydro forecasts reactive pole replacements to remain in the historic range. Please note that poles may also be replaced on an individual basis proactively as part of planned programs but Toronto Hydro is unable to provide this information.
Toronto Hydro is unable to provide a breakdown of individual pole replacements by pole type. Toronto Hydro often replaces existing concrete poles with wood poles. Furthermore, as noted in 2B-SEC-51, Toronto Hydro does not track the removal of assets within its system.

c) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-51, specifically poles under the “Overhead Circuit Renewal”, “Overhead Infrastructure Relocation”, “Rear Lot Conversion”, and “Box Construction Conversion” categories of that table. Those pole replacements were conducted almost entirely on an area rebuild basis. Please also reference the notes contained in 2B-SEC-51, as information system constraints limit Toronto Hydro’s ability to report removals from the system for non-like-for-like configurations (e.g. rear lot, box construction).
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 38:
Reference(s): Exhibit 2B

For each of the asset categories in Tables 2 to Table 6, please provide the asset renewal rate by asset class for each of the years 2015 to 2019 and forecast for 2020 to 2024.

RESPONSE:
Please refer to Toronto Hydro’s response to interrogatory 2B-AMPCO-52.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 39:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 2

a) Please provide a copy or link to the reference materials utilized by THESL to implement the Common Networks Asset Indices Methodology (CNAIM).

b) Page 2: Please define “remaining serviceable life of physical assets”.

c) Page 2: THESL indicates it uses condition information to support tactical and strategic investment planning decisions.

Please discuss if and how THESL utilizes maintenance records to support tactical and strategic investment planning decisions.

RESPONSE:

a) Please use the link below for the DNO Common Network Asset Indices Methodology:


b) Remaining serviceable life is not a technical term. It was used to describe the period where an asset progresses from its current state to one where the asset is deemed to require intervention. The ACA methodology has a forecasting module which is used to predict the future health score of an asset. The time taken for an asset to progress to
HIS (“end of serviceable life”) can be considered to be the remaining serviceable life of an asset in this context.

c) The information in maintenance records is used to derive condition information which serve as inputs to the ACA methodology used to calculate asset Health Indices. The ACA results are in turn used to support tactical and strategic investment planning decisions as described in Exhibit 2B, Section D, Appendix C, Page 2, Lines 22 - 31.

Maintenance records on their own (separate and distinct from asset Health Indices), may also be used to support tactical and strategic decisions. For example:

- **Tactical**: Please see Toronto Hydro’s response to interrogatory 4A-Hann-81. Deficiencies identified and contained in maintenance records are reviewed by the Maintenance Planning function as part of the Asset and Program Management program as described at Exhibit 4A, Tab 2, Schedule 9, page 16, lines 9-10. The Maintenance Planning function makes tactical decisions to address specific deficiencies through either the Corrective Maintenance program (Exhibit 4A, Tab 2, Schedule 4) or the Reactive and Corrective Capital program (Exhibit 2B, Section E6.7).

- **Strategic**: Trends in maintenance records (e.g. particular types of transformers exhibiting considerable corrosion leading to oil leaks) are monitored and strategic investment decisions relative to asset types, or batches of assets are routinely made.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 40:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 3

EB-2016-0025 LDC Co_Business Plan Appendix 9-B (Attached as Appendix A)

Ref: 2B Section D Appendix C P3

THESL indicates “Asset age is also typically a significant factor in the calculation of HI scores, partly due to the fact that age bears a strong statistical relationship with probability of failure.”

Ref 2: EB-2016-0025 LDC Co_Business Plan Appendix 9-B (Attached as Appendix A)

As part of the amalgamation of Horizon, PowerStream, Enersource and Hydro One Brampton, Vanry & Associates (Vanry) was retained to undertake a Distribution Assets Due Diligence Review of the four utilities. The report is filed as Appendix A to AMPCO’s interrogatories. Vanry was required to undertake an assessment of each of the four utilities best practices in the areas of ACA (HI) and capital investment planning. The assessment was based on Vanry’s set of criteria that it believed represented best performance in the areas of ACA and investment optimization.

At Page 15 of the report, Vanry provides the criterion definition for Condition Assessment that it believes represents best practice. The assessment against the criterion relates to PowerStream. Vanry indicates best practice is that factors related to criticality and obsolescence are excluded and age is not included as a condition criterion.
a) Please discuss if THESL’s ACA methodology includes criticality or obsolescence.

b) Please confirm THESL’s new ACA methodology includes age as a condition criterion.

c) Vanry indicates there have been recent improvements in the industry that includes a multiplicative approach to health indexing as opposed to the additive approach. THESL previously used the additive approach. Please discuss if THESL considered adopting this new industry innovation of the current methodology prior to adopting a new ACA methodology in 2016. If not, why not?

d) On page 43 of the report, Vanry states “All four utilities use health to modify effective age which is appropriate.” Please discuss THESL’s awareness of this approach.
Please discuss how THESL has calibrated its failure probability estimates to actual failure rates.

RESPONSE:

a) Criticality and obsolescence are not included as part of Toronto Hydro’s ACA methodology to calculate the Health Score of an asset.

b) Toronto Hydro does not use age as a condition criteria. As per the CNAIM methodology, age is a part of the formulation used to calculate the Initial Health Score. Condition criteria (via the Health Score Modifier) are applied to the Initial Health score to calculate the Current Health Score.

c) Toronto Hydro’s new ACA methodology is a multiplicative approach.

d) Toronto Hydro cannot comment on the specific approaches taken by the four utilities.

e) Toronto Hydro’s hazard rate distribution functions, which are used to determine the failure probability estimates for its assets, are typically calibrated to the Mean Useful Life values as defined in the 2009 Kinectrics report, “Toronto Hydro-Electric System Useful Life of Assets”. As noted on page 1 of this report, Kinectrics’ useful lives “are compiled from several different sources, namely, industrial statistics, research studies and reports (either by individuals or working groups such as CIGRE) as listed in Section 54 of this report, and Kinectrics experience.” Please refer to Toronto Hydro’s

1 Toronto Hydro has provided a copy of this report as Appendix A to its response to interrogatory 2B-SEC-38.
response to interrogatory 1B-CCC-12 for more information on the definition of Useful Life and how it relates to the expected life of assets.
PROJECT TITAN

DISTRIBUTION ASSETS DUE DILIGENCE REVIEW

Report prepared for:

Jim Harbell, Stikeman Elliott
Mark Rodger, Borden Ladner Gervais
Robert Hull, Gowling Lafleur Henderson
TABLE OF CONTENTS

Executive Summary .................................................................................................................. 4
Introduction and Approach ....................................................................................................... 6
  Summary of Approach ........................................................................................................... 6
  Scope of Due Diligence Review ............................................................................................. 7
Observations and Assessments ................................................................................................. 9
  PowerStream ....................................................................................................................... 9
  Horizon Utilities ................................................................................................................. 17
  Hydro One Brampton ......................................................................................................... 25
  Enersource ......................................................................................................................... 33
Conclusions ............................................................................................................................ 42
  Alignment of Methodologies ............................................................................................... 42
  Best Practice Assessment .................................................................................................... 45
The information and methodologies outlined herein are proprietary, trade secret, and their expression in this document is copyrighted, with all rights reserved to Vanry and Associates, Inc. Copying or distributing this material without prior written permission from Vanry and Associates, Inc. is strictly prohibited.
EXEcutive Summary

Vanry + Associates, Inc. (VAI) was engaged through Horizon Utilities, on behalf of counsel, to undertake an independent, third-party review in support of the due diligence process related to the potential merger of four Local Distribution Companies (LDCs). The four LDCs are: Enersource Hydro Mississauga (EHM), Horizon Utilities Corporation (Horizon), PowerStream Inc. (PS), and Hydro One Brampton Networks Inc. (HOBNI). The scope of the review was to evaluate the respective Asset Condition Assessment (ACA) methodologies and resulting capital investment planning processes, as well as to assess the overall asset health and subsequent 20-year investment for each of the four LDCs.

The review was conducted under a compressed time frame. VAI’s proposal was accepted on May 8, 2015. The Non-disclosure agreement (NDA) necessary to enable VAI to have access to the LDCs’ documentation to conduct the work was provided to VAI on May 13, 2015 and executed by both parties that same day. Horizon, on behalf of the LDCs, began uploading copies of the respective ACA reports as well as the distribution system plans (DSP) containing the capital investment plans to VAI’s document storage on May 14, 2015. The final ACA was uploaded to the site on May 19, 2015.

VAI conducted in person interviews at each of the LDCs May 19, 2015 through May 21, 2015. During these interviews additional supporting documents were provided. The initial draft report was delivered May 22, 2015 for review by counsel.

The ACA practices at Horizon, HOBNI, and Enersource are generally well aligned. The approach at PowerStream is somewhat different, but consistent in the sense that it is a more advanced version of the same concept in use at the other three. There is no reason to believe that a merger would result in any major philosophical change of any of the ongoing renewal approaches. It is possible that applying the economic life methodology used at PowerStream to the assets at the other three utilities (and to PowerStream’s cable program) would result in somewhat lower renewal spending, although this is hard to predict with certainty.

All four utilities are aligned in terms of pursuing minimum life-cycle cost as the basis for renewal spending. All are committed to a customer-focused business case approach to making spending decisions. This is important because it means that changes that come about from a possible merger of the asset management practices will tend to be improvement opportunities at the margin due to minor variations in expertise. The asset classes considered, the approach to condition assessment and failure projection, and the resulting capital spending recommendations are generally compatible.

There is a range of variation among the methodologies used by the four LDCs. In most cases the variation is due to differences in their stages of evolution in a particular area. One result of the variation is that there are a number of complementary strengths among the four LDCs. Where more than one LDC is using best practice methodologies or approaches, they are generally consistent though not necessarily the same.

In our review, we did not identify any aspects of an individual LDC’s approach, or anything in the potential combination of LDC’s that we would expect to result in dramatic changes in overall spending levels in a combined LDC. We do believe that certain approaches among the LDCs are sufficiently different that combining the four could lead to the potential for reductions in overall spending. We also see a distinct possibility that a merged LDC, adopting a common set of leading practices, could lead to the overall capital investment program being redistributed among the respective systems in proportions that are different than the current allocations. This is due in part from different assessments of criticality and in part in recognition of the current variations in system performance and failure rates among the four LDCs. In short a merged entity would expect to see funding flowing to the areas of greatest value, or greatest risk potential. We observed from the reports that the range of need among the systems varies sufficiently that spending might flow to the portions of the combined system with the greatest need.
The Asset Management philosophies among the four are consistent and generally well aligned. The skills and capabilities that we observed also appear to be complementary. Given that several of the AM organizations appear to be resource constrained, there is the potential for a combined LDC to be able to produce significantly better AM results through a combination of talent that has sufficient resources to address a broader scope of AM activities.

Each of the four LDCs has processes in place to address Renewal, Access and Service investments. The processes in use by the LDCs to assess and validate Access and Service investments are generally consistent, with minor variations. Each of the LDCs appears to have applied a sound set of standards and criteria to evaluating the Access and Service investments, including them in their optimization/prioritization processes. These investments are largely non-discretionary with limited latitude in timing. Given the levels of rigour and consistency within each of the LDCs with regard to these investments, we focused the majority of our findings and conclusions on those areas where differences exist and where insights may be gained for a merged entity.

The capital renewal spending plans at all four utilities are increasing based in part on the application of their ACA processes. This is consistent with industry experience: implementation of asset management helps utilities identify and justify the need for increased spending to renew aging infrastructure. All four utilities have applied sound judgment and methodologies to develop achievable plans to meet this need.
INTRODUCTION AND APPROACH

Vanry + Associates, Inc. (VAI) was engaged through Horizon Utilities to undertake an independent, third party review in support of the due diligence process related to the potential merger of four Local Distribution Companies (LDCs). The four LDCs are: Enersource Hydro Mississauga (EHM), Horizon Utilities Corporation (Horizon), PowerStream Inc. (PS), and Hydro One Brampton Networks Inc. (HOBNI). The scope of the review was to evaluate the respective Asset Condition Assessment (ACA) methodologies and resulting capital investment planning processes, as well as to assess the overall asset health and subsequent 20-year investment for each of the four LDCs.

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VAI conducted in person interviews at each of the LDCs May 19 through May 21. During these interviews additional supporting documents were provided. The initial draft report was delivered May 22, 2015 for review by counsel.

Summary of Approach

In undertaking the review, VAI applied a methodical approach consisting of:

1. document review
   a. ACA
   b. DSPs containing capital investment plans
   c. Other supporting documents provided by the LDCs

2. development of lines of inquiry specific to each LDC regarding their respective
   a. ACA
   b. DSP
     i. Capital investment planning including investment optimization or ranking
   c. AM processes and philosophies
   d. Resources and competencies related

3. interviews with the respective LDCs
   a. ensured that VAI has a clear and accurate understanding of the processes used by each of the LDCs,
   b. the ACA and capital investment planning process was investigated in sufficient detail to enable VAI to make meaningful assessments

4. review of additional supporting documents provided during the interview

5. generate observations and assessments for each LDC

6. generate comparisons of the processes and results produced by the LDCs

Based on the results of our reviews and discussions with the utility personnel, this report provides observations, assessments and conclusions regarding:

1. The development of ACAs and capital investment plans by each of the LDCs
2. The alignment of the methodologies employed by the LDCs with reference to:
   a. each other
   b. industry leading practice
Scope of Due Diligence Review

The scope of the review was a narrow band, high focus review. The following paragraphs provide more detail regarding what was included and excluded from the detailed scope of the review of the ACA and capital investment planning processes.

Asset Health Assessment Methodology Review Distribution and General Plant Assets

The scope of the review of the ACA methodology and results consisted of the following:

- Reviewed and compared the methodology used by each LDC’s ACA to undertake a probable determination of remaining asset life against current methodologies employed by leading practitioners of asset management;
- Reviewed and compared the asset categories employed by each LDC in their respective ACAs;
- Developed assessments based on our review of the shared materials and our own professional experience, as to whether the asset categories identified by each LDC in their respective ACA adequately represent the assets health which could materially impact the total renewal investment;
- Compared the condition parameters utilized by each LDC in calculating asset health and the asset health distributions for each asset category; and
- Compared the assumptions used by each LDC to develop the failure curves for each asset category.

The following activities were specifically excluded from the scope for this phase:

- Validation of the raw data quality (accuracy and completeness) used in the ACA calculations;
- Validation or re-creation of the asset health calculations used to determine the asset health distributions and the ‘flagged-for-action’ values;
- Detailed calculations or detailed assessments regarding the impact of changes to the assumptions in any of the ACAs; and
- Analysis of and/or development of combined ACAs for the potential merged entity.

Capital Investment Review

The LDCs also required an assessment of the appropriateness of the proposed renewal investment of each LDC given the results of their ACAs. System Access and System Service historical expenditures, known projects, and project prioritization methodologies were investigated for this review.

The detailed scope for this task consisted of:

1. Interviews with the relevant participants that developed the capital investment plans identified in the DSPs and/or AMPs.
   a. We spoke with at least one representative from each of the utilities and spent a half day discussing:
      i. Assumptions and approaches to translating corporate objectives into ACA inputs and performance outcomes;
      ii. Methodologies for translation of ACA into capital investment plans;
      iii. Assumptions used in both the ACA and in the capital investment plans including those related to constraints on spending, systems and resources; and
      iv. Other questions that surfaced during our review of the ACA.
2. A review of existing supporting documentation utilized in the development of each of the investment plans. We received what we understand to be each LDCs foundational documentation and defined methodologies for developing capital investment plans;
3. Using our experience in Asset Management and work with other utilities we undertook reasonability test and assessment of the planned outcomes (such as future asset conditions) contained in each of the plans, based on information provided by the LDCs; and
4. Validation of the assumptions (such as capacity constraints) used to tailor the optimal investment profile identified in each of the ACAs, based on the information and fact base supplied by the LDCs in their documentation and through our discussions with utility personnel.

The following activities are specifically excluded from the Scope of Work for this phase:

• Re-engineering the process used to develop the proposed investment plan;
• Providing an opinion of the appropriateness of corporate and business units’ strategic and tactical targets; and
• Reviewing the content and completeness of the DSP and/or AMP.
Observations and Assessments

In preparing our findings we adopted a format that we believe will enable a ready comparison between the four LDCs. While each of them demonstrates areas of strength, there are opportunities for each of the four to learn from and support the others.

Three of the four companies use the same external consultant for either conducting or auditing their ACAs. PowerStream had previously used the same consultant but has since moved the work in-house and has engaged with other consultants to provide input into its ACA process. References to the external consultant in the paragraphs below are to the consultant used by Enersource, Horizon and HOBNI.

PowerStream

The VAI consultant (Stewart Ramsay) met in person with PowerStream on May 19 to review the ACA and DSP materials that PowerStream provided and to address specific questions VAI had regarding the ACA process, methodology and its use in developing the capital investment plans. We noted that PowerStream transitioned away from external consultants to prepare the ACA. It currently prepares the ACA internally using its own staff, though it may rely on external expertise in support of components of the ACA.

For PowerStream, the meeting was attended by:

- Irv Klajman, Director, Asset Investment Planning
- Riaz Shaikh, Manager, System Planning
- Phil Dubeski, Manager, Asset Planning and Agreements
- Shelly Cunningham, SVP, Engineering Services

The meeting was productive and provided VAI with greater clarity around the process, the data elements used, the respective roles of different parts of the PowerStream organization in the development of the ACA, and most importantly an understanding of how the ACA results are used in the identification and development of capital investments.

Our observations and assessments are summarized, by topic, in the following paragraphs.

ACA

1. Asset Categories

PowerStream uses internal personnel for the development of the ACA. Data is provided by a combination of internal resources and testing contractors.

The determination of Asset Categories is based on the historical work done; and has been added to over the last few years to address the observed need to separate asset types into more distinct sub-groups based on the uniqueness of factors that affect end of life. PowerStream’s ACA is focused on the Asset Categories identified in the table to the right.

Assets are generally well subdivided for Health Indexing purposes; some multipliers are included (e.g. tap-changer, non-TR XLPE cable). Further stratification may be beneficial to zero in on the highest-risk sub-populations. For instance, currently PowerStream treats poles as a homogeneous asset group. They have also acknowledged that the risk/replacement cost trade off for a 100-ft pole is different than for a 40-ft pole. We would expect that over time
PowerStream would move to separate these two into sub-classes.

Our view is that PowerStream evaluates a large and growing number of assets. Presumed run to fail assets (e.g., single-phase, pole-mount transformers) are evaluated in order to justify the run-to-failure strategy.

Three-phase pole mount transformers are not treated as run to fail. PowerStream has observed that the predominant failure cause for these assets is overloading. As a result PowerStream is proactive in replacing these transformers when they are approaching their loading limits as they are expensive and can be used in other areas of the system. This type of proactive replacement, or relocation/redeployment is consistent with best practice Asset Management.

PowerStream has identified additional assets to be added to the ACA or to be further subdivided in the ACA. This decision appears to be based on both emergent failure issues and as part of a plan for proactive expansion of the ACA process. PowerStream acknowledges that there could be value in the continued expansion of the ACA to other asset types.

The level of rigour applied is consistent across all classes with the exception of underground cable, which uses a prioritization index rather than the economic life approach. PowerStream is working to expand the list of assets included in the economic life type ACA analysis. We see this as a positive step that will improve the results for PowerStream.

Protective relays and communication systems are not evaluated in PowerStream’s ACA. This is inconsistent with better performing utilities as these assets are often high-value, high risk impact assets.

a. Impact on renewal investment plans

For PowerStream, as is the case with most utilities, the somewhat limited detailed stratification to identify specific problem types or highly critical assets makes planning difficult. It tends to limit the ability to undertake more meaningful “bottoms-up” cost assessments which leads to a top-down spending cap approach to estimating spending need.

PowerStream is conscious in undertaking a clear bottoms-up as well as a top-down approach to system investment analysis.

Limited ability to do more detailed and predictable scenarios on asset failure related spending can become problematic. PowerStream has done good work in its ACA, advancing to more accurate approaches and is clearly leveraging the value of that work in the development and influence of its investment plans. We believe that further work in this area on both granularity of assets and asset HI data will enable PowerStream to increase the predictability and accuracy of its asset failures, as well as accurately predict impacts on system performance resulting from any given investment or renewal plan.

PowerStream does undertake a review of ACA results against recent performance by asset category to validate the results of the ACA. This is consistent with best practice. PowerStream acknowledges that it is seeing evidence for the need for additional stratification within asset groups to allow it to refine its failure rate analysis. This is based on failures of sub-components within its existing asset groups. This is a normal progression and indicative of best practice approaches.

There is the potential that the results of the ACA, to the extent they are not fully accurate, are pointing to somewhat less optimal renewal investment profiles. We recognize that this is also a common characteristic of utilities that have embarked on the HI and ACA path and are continuing to refine and improve their HI and ACA through better data and greater stratification. PowerStream’s ACA results and the impact that they have on the investment plans are significantly better than the results it was able to produce in prior years and it
continues to improve the quality of the ACA and its ability to use the results to create well informed investment programs.

2. Condition Parameters

The condition parameters have been developed and evolved in a joint effort between consultant teams and PowerStream. This is a best practice approach which provides PowerStream with insights from consultants that may have a larger view of the industry and issues that others are facing. Moreover, it creates the opportunity for knowledge transfer from the consultants to the PowerStream team. The formulations appear to be complete and are consistent with what we would expect to see within leading utilities.

PowerStream’s asset condition data for stations assets, switches, and switchgear are stored mainly in the Cascade tool. Data for the remainder of the assets are stored in GIS or Excel. PowerStream is investigating ways to automate the link between their databases and ACA which would enable regular and routine updates of asset Health Indices based on most recent inspection and test results. This, combined with running the ACA in house, is a best practice approach. In contrast to an annual ACA process, this approach enables PowerStream to see the impacts of sudden or significant changes in asset condition on its current investment plans and its current resources.

The condition parameters used by PowerStream and the data that it collects in support of those parameters are within normal range for best practice, especially for stations’ assets such as transformers and breakers where testing and inspection data are available.

Health Indices are not calculated for assets with limited or no condition data (cable); this is appropriate.

We did not inquire with PowerStream regarding its standards for determining if it had a valid HI or if there are standards within PowerStream for determining required data availability or minimum data needed for valid HI calculation. We did observe that PowerStream does not do an HI calculation where it does not have available condition data.

Non-condition-related parameters such as age and obsolescence are generally excluded from the formulations. Obsolescence is handled as a factor in consequence of failure or cost of maintenance. Both of these are consistent with best practice approaches.

CAPITAL INVESTMENT PLANS

1. Assumptions and Approach

ACA is the primary driver for renewal investments, which PowerStream bases on assets at end of economic life.

Assets not evaluated in the ACA are replaced based on inspection criteria. PowerStream applies a standardized approach to ensure consistent recommendations across inspection contractors, including: definitions, pictures, etc. PowerStream audits a percentage of the inspection reports. PowerStream has also separated the inspection work from the execution of the work. As a result those doing inspections have no vested interest in the volume of replacement work identified by the inspections.

Justification is based on a business case process, which includes estimates of customer outage risk. Other parameters such as safety are considered qualitatively. This method is not applied comprehensively, presumably only in cases where the ACA model can provide risk values.

Planning and AM work closely together to coordinate projects so that system expansion and investments generated by other drivers (road widening, etc.) are leveraged to incorporate or optimize assets identified in the ACA as in need of replacement.
2. ACA Translation

“End of economic life” assets are the basis for spending renewal levels. The underground cable program is based on a prioritization method, assuming that all cables must be replaced or injected (a form of life extension or failure prevention that can be done only prior to a certain level of degradation) as they age. PowerStream uses the benefit/cost analysis from its ACA as an input into the cable replace/inject decisions.

Health Index is used to adjust effective age in cases where the health is lower than expected given the age of the asset.

End of life programs are reviewed by SMEs for reasonableness and smoothed to manage resources and spending. For instance, ACA identifies 700 pad mount switchgear at end of life, but the annual replacement program is much smaller. This is based on a combination of capital and resource constraints. The post-ACA adjustments are based on inspection results which provide PowerStream with further granularity and prioritization of end of life assets.

PowerStream is able to compare capital and corrective maintenance spending, modeled as part of the risk of failure, in their trade-off between replacing and not replacing (i.e. "Based on our current maintenance regime, when should the asset be replaced?"). PowerStream does not yet routinely evaluate the cost/benefit trade-off of increasing or decreasing their maintenance program (i.e. "If we increased maintenance, could we cost-effectively make the asset last longer?").

Proposed programs are scored for risk and value using a standardized approach. Staff were recently trained to ensure consistent scoring is applied across attributes and among the different proponents. PowerStream has a manager level person dedicated to ensuring consistency in the understanding and the application of the scoring criteria.

3. Constraint Analysis

Programs are smoothed to manage resource and spending impacts. As mentioned above PowerStream relies on inspection data and other fact based decision support in setting the priorities in smoothing. This is consistent with better performing utilities and has been received well by the OEB when presented by PowerStream and by other utilities in the province.

As with most utilities there is a category of spending that is “mandatory”. These must-do projects are identified as such in the prioritization process. PowerStream appears to apply similar clear standards and rigour to defining and screening mandatory spending as to those used in scoring projects on value and risk. The lack of such standards is an issue for many utilities. Loose definitions result in large percentages of their overall spending being deemed mandatory. This is not the case with PowerStream and its mandatory spending levels are in keeping with what we would expect to see for Ontario. PowerStream’s application of the mandatory filtering criteria is a best practice approach.

4. Reasonability Testing

We observed a significant amount of reasonability testing within the PowerStream processes. In addition to the quantitative analysis, there is a subjective review by AM team and SMEs. To the extent that the results of the quantitative analysis do not align with the SME’s views or expectations, PowerStream undertakes additional analysis until there is a reconciliation. The results of that reconciliation are used to either improve the quantitative analysis or help expand the understanding of the AM and SME team.

Costs and benefits to determine end of life are explicitly evaluated from the customers’ perspective. This step depends on assumed outage costs, which is an opportunity for future improvement for PowerStream. Given the nature of regulation and pricing in the province it may be an opportunity for PowerStream to work with other utilities to develop consistent values for all of the GTA in coordination with Toronto Hydro, which is currently undertaking a customer survey.
5. **Optimal Investment Profile**

PowerStream has been using multivariate optimization analysis for a number of years. It explicitly examines and scores the value of the investment across the range of corporate objectives. It also explicitly scores the investment with respect to the risk to the business (including personnel and public) if the investment is not undertaken. Our understanding is that PowerStream does the optimization for all capital investments within the organization.

The optimization methodology is consistent with best practice. However, best practice utilities apply the approach to both capital and OMA. Doing so ensures that, for example, capital for breaker replacement is being evaluated against maintenance for tree trimming. This helps to drive expenditures to the greatest value area for the business and the customers.

PowerStream is investigating new decision support tools that would enable it to integrate the ACA results into the optimization analysis. This would be a leading practice.

**RESULTING EXPENDITURE LEVELS**

The approach used by PowerStream may result in lower replacement rates for station assets compared with the other three utilities. For instance, PowerStream has a population of 71 station transformers, none of which is due for replacement in the next 20 years. By contrast, HOBNI’s ACA recommends replacement of six station transformers in the next 20 years (three immediately) from a population of only 20. While these variations could be due to differences in actual condition of the assets, we believe that the refinements that PowerStream has made over the last several years, since it took over the ACA process, have helped it fine tune its spending needs.

PowerStream does have a large cable replacement/ remediation program based on assumptions regarding asset end of life age. PowerStream believes that its analysis supports a strong correlation between age and replacement timing.

Overall we believe that the expenditure levels resulting from the ACA and capital investment process are the result of a good process. PowerStream has applied many best practices in its processes and the expenditure levels appear to be consistent with what we would expect they need to be.

**BEST PRACTICE ASSESSMENT**

One of the requests made of VAI was to undertake an assessment of each of the LDCs against best practices in the areas of ACA (HI) and capital investment planning. The following table provides a summary of the assessments that we have made for PowerStream. In undertaking the assessment we have used a set of criteria that we believe represent best practice performance in the areas of ACA and investment optimization. The criterion and their definitions as well as our observations of PowerStream against each is included in the table below.

<table>
<thead>
<tr>
<th>CRITERION DEFINITION</th>
<th>VAI ASSESSMENT: POWERSTREAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determining End of Life</td>
<td>End of life is determined using an economic life model as part of the ACA. Not all assets are modeled this way yet, so other means are used to fill in the gap, (e.g. prediction of failure rate health assessment). Run-to-fail strategies have supporting analysis.</td>
</tr>
<tr>
<td>CRITERION DEFINITION (CONT’D)</td>
<td>VAI ASSESSMENT: POWERSTREAM (CONT’D)</td>
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<tr>
<td>-------------------------------</td>
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<tr>
<td><strong>Business Case</strong>&lt;br&gt;Spending recommendations have an accompanying business case that summarizes the problem statement, compares alternatives, and makes a recommendation. All costs and benefits are also quantified from the customers’ perspective; alternatives including the do-nothing alternative are considered; assumptions are stated explicitly and quantitatively.</td>
<td>Cost/benefit analysis including customer costs performed for programs based on ACA economic models. For assets not modeled in detail, business case includes a narrative description of benefits. Prioritization scoring method used to compare projects. Benefits of projects are scored in this way, but are not explicitly compared with costs. Many business cases are narrative-based.&lt;br&gt;Do-nothing is explicitly stated as an alternative. Other alternatives may be described and evaluated for comparison.&lt;br&gt;Alternatives to replacement are considered by the SMEs on an asset-by-asset basis for modeled assets (station transformers, breakers, cables) and programmatically for dispersed assets.&lt;br&gt;Benefits and risks are based on customer values (e.g. safety, reliability, environmental).</td>
</tr>
<tr>
<td><strong>Long-Range Projections</strong>&lt;br&gt;Aging asset populations include a projection of future spending needs based on expected future degradation and risk.</td>
<td>Long-range projections are provided in the ACA, based on the life-cycle cost analysis for each asset class. These are incorporated into the long-range spending plan.</td>
</tr>
<tr>
<td><strong>Prioritization/Optimization Across Programs</strong>&lt;br&gt;Spending on replacement, refurbishment, maintenance, and other options is directly compared in equal terms to optimize spending plans and to prioritize across programs. Capital and OMA expenditures are optimized in the same process using the same or comparable criteria.</td>
<td>Prioritization process compares spending across assets in equal terms based on the standard scoring scale. Renewal programs should be evaluated in ACA and prioritized in the value model based on the same assumptions for quantifying risk and value. For example, asset criticality should be quantified in terms of its effects on the prioritization parameters. (Alternatively, prioritization parameters could be adjusted to reflect the estimated customer costs in the ACA.) This will foster consistency, simplify scoring, and help ensure “apples-to-apples” comparisons.</td>
</tr>
<tr>
<td><strong>Use of Subject Matter Experts (SME)</strong>&lt;br&gt;Tacit knowledge of subject-matter experts is incorporated into the assessment process. Attention is focused on their areas of expertise (e.g. how best to assess condition) as opposed to complex questions outside it (e.g. how many transformers should we replace each year). SME input is documented explicitly for review and improvement over time.</td>
<td>Internal SMEs reviewed, modified, and approved the Health Index formulations and failure scenarios.</td>
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| **Risk Assessment**  
Asset risk is quantified in terms of actual failure probability and expected consequence cost of failure in terms that can be used in business cases and the budgeting process. Risk is included in business cases both as a benefit of spending (e.g., avoided risk) and as part of the cost of the work (e.g., risk of cost overrun).  
Failure probability is an estimate of actual failure, which has been calibrated to even recent failure history or industry-standard data.  
Consequences of failure are quantified for the asset classes modeled. They are based on estimated actual customer costs but not yet calibrated with the prioritization model.  
Avoided risk is explicitly included in the business case where available. Not explicitly calculated for the cable program. |
| **Condition Assessment**  
Asset conditions are assessed relative to end-of-life failure criteria (i.e. Health Index). Health Index includes relevant parameters for predicting failure based on known degradation processes, and excludes other factors such as those related to criticality or obsolescence. Age is not included as a condition criterion.  
Health Indices are based on major degradation processes and end of life criteria. The formulations are generally within the range of best practice, although recent improvements in the industry (e.g. multiplicative formulation) have not been applied. PowerStream has a strong testing and inspection program with good data availability.  
The multiplicative approach to health indexing is in contrast to the additive approach used by all four utilities in this review. It is a recent industry innovation wherein condition parameters are multiplied together rather than added. It avoids some of the common problems: “masking,” where a bad test result is hidden amid several good ones, and validity, where there are not enough data available to calculate a valid health index.  
Age is excluded from most formulations.  
Factors related to obsolescence or consequences (e.g. oil circuit breakers, PCB transformers) are excluded from the formulations. |
| **Failure Probability**  
The meaning of failure is clearly defined and consistently applied (e.g. end-of-life failure events that require replacement). The likelihood of failure is determined based on condition, age, and historical data.  
Definition of “failure” is clearly stated as failure scenarios. Failure probability is estimated based on correlations between age and failure rate, adjusted by Health Index. |
| **Consequences of Failure (Asset Criticality)**  
Failure consequences are monetized and related directly back to the customer as an outage cost or willingness-to-pay social cost. Consequence costs are intended to reflect the perceived cost to the customer. For example, how much would a ratepayer be willing to pay on a monthly basis to reduce or avoid power outage events? Where appropriate, multiple failure scenarios are considered and weighted according to their relative likelihoods.  
Consequences of failure are monetized from customers’ perspective and are expressed in terms that can be used in decision-making outside the ACA, e.g. prioritization and business cases.  
multiple failure scenarios are explicitly considered. |

**Processes Documentation**

Work flow processes are documented for significant tasks within the organization. The roles and responsibilities of each individual are documented and reviewed on a regular basis. The required flow of data to support asset management is documented. This includes data collection and storage, data requirements for program development, and data requirements for project justification and prioritization in the budgeting process.

**VAI Assessment: PowerStream**

ACA is performed in-house, therefore the ACA report and DSP summarize the process.

Data requirements are documented in the ACA, e.g. test and inspection results for calculating health. Most needed criticality data is contained in Cascade.

Project development using the outputs of the ACA is somewhat subjective and probably difficult to systematize. PowerStream is relying on sound engineering judgment to turn the raw results of the ACA into executable programs. A more rigorous cost/benefit approach, leveraging the economic life tools in the ACA, is possible and may strengthen the results.

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**OTHER OBSERVATIONS RELATIVE TO ASSET MANAGEMENT**

In many instances we see that PowerStream is near the front of best practice, and it fully acknowledges that it is still working and still needs to improve other aspects of its processes.

PowerStream has a clear focus on renewal spending to provide value to customers, as opposed to a more technical approach focused on the assets. The result is that PowerStream is comfortable not replacing old station assets if they don’t carry a lot of risk and if the cost of replacing those stations would take resources away from higher value, higher impact investments.

PowerStream does have areas that it should focus on improving. These include:

- Continuing to strengthen its approach used for the cable program, which is a large line item, by applying the economic life approach that it uses to assess other assets;

- Assumed values for customer outage cost could be improved through customer survey, independent study, coordination with local peers, or by using the same values used in the project prioritization method (so ACA projects are identified and justified in the same terms they are prioritized for budgeting). PowerStream participated in a CEATI study that may be a good source of information once it is published; and

- Expanding the number of asset categories and sub-categories that are explicitly studied in the ACA.
Horizon Utilities

VAI consultants (Stewart Ramsay and Darin Johnson) met in person with Horizon Utilities on May 20, 2015 to review the ACA and DSP materials that HU had provided, and to address specific questions VAI had regarding the ACA process, methodology and its use in developing the capital investment plans. We noted that Horizon uses an external consultant to prepare the ACA based on input from Horizon.

The meeting was attended by Jim Butler, Director, Engineering & Operating for Horizon.

The meeting was productive and provided VAI with greater clarity around the process, the data elements used, the respective roles of Horizon and its consultant in the development of the ACA, and most importantly an understanding of how the ACA results are used in the identification and development of capital investments.

Our observations and assessments are summarized by topic in the following paragraphs.

ACA

1. Asset Categories

Horizon uses an external consultant for the development of the ACA. Horizon provides the input data, but relies heavily on the external consultant for the calculations and the methodology.

The determination of Asset Categories is done in collaboration with the consultant based on the combined experience of Horizon and the consultant, as well as Horizon’s knowledge of assets that have significant financial or reliability impact on the system. Horizon’s ACA is focused on the Asset Categories identified in the table to the right.

Within the main asset categories in the Horizon ACA some assets are further subdivided, e.g. circuit breakers broken into air and oil for Health Index (HI) purposes; cable split into XLPE, PILC, and secondary. This is in recognition that the HI factors for these asset types differ sufficiently from one another that they require distinct analysis and review. This is a positive practice, consistent with better performing utilities. For Horizon this stratification is limited and has been based on its experience with specific sub-groups of assets that have been problematic, “a few bad-actors”. Further stratification may be beneficial such as tap-changers, type-U bushings, etc.

When examining Horizon’s ACA process, in industry terms, Horizon assesses a large number of assets. We do note that the level of rigour and detail drops off after the most critical assets. This is not unusual and is common among utilities that have recently begun using Health Indices and Condition Assessment. From our discussions with Horizon, it appears that Horizon expects to continue to increase the rigour and data collection for these sub-categories as well as add new categories to improve the granularity of its assessments. Our understanding is that Horizon does not have a plan for targeting specific assets but does expect to make these additions to the ACA based on seeing significant anomalies or variations in the ACA results. This is also a common practice, though leading utilities tend to have a more deliberate approach to looking for and assessing the next level of detail for the HI and ACA.

Protective relays and communication systems are not evaluated in Horizon’s ACA. This is inconsistent with better performing utilities as these assets are often high-value, high-risk impact assets.
a. Impact on renewal investment plans

For most utilities, and in our view this holds for Horizon, the somewhat limited detailed stratification to identify specific problem types or highly critical assets, makes planning difficult. It tends to limit the ability to undertake more meaningful “bottoms-up” cost assessments which leads to a top-down spending cap approach to estimating spending need. The limited ability to do more detailed and predictable scenarios on asset failure related spending can become problematic. Horizon has done good work in its ACA and it is clearly leveraging the value of that work in the development and influence of its investment plans. We believe that further work in this area on both granularity of assets and asset HI data would enable Horizon to increase the predictability and accuracy of its asset failures, as well as accurately predict impacts on system performance resulting from any given investment or renewal plan. This would tend to improve the quality and transparency of the renewal and investment plans overall and increase credibility with the OEB and interveners in rate proceedings.

Horizon does not undertake a routine review of ACA results against recent performance by asset category to validate the results of the ACA. This is inconsistent with best practice. Horizon has recognized the need for this on certain asset types, particularly where data is limited. It has not, however instituted this as a standard check. There is the potential that the results of the ACA, to the extent they are not fully accurate, are pointing to somewhat less optimal renewal investment profiles. We recognize that this is also a common characteristic of utilities that have embarked on the HI and ACA path. That Horizon has not yet begun this check as a standard process is not a particular concern, provided that it has plans to continue in that direction. Horizon’s ACA results and the impact that they have on the investment plans are significantly better than the results it was able to produce prior to 2012.

2. Condition Parameters

Based on our review of the ACA and our discussions with Horizon we understand that the condition parameters were proposed by the external consulting firm and reviewed and approved by SMEs within Horizon. We also note that Horizon moved to the HI based ACA in 2012 and changed external consultants at that time. Prior to 2012 Horizon was working with a consultant that used an age based approach to conducting ACAs.

The condition data is collected, reviewed and provided to the external consultant by Horizon. Some of the condition data appears to be collected by Horizon’s testing contractors, which is fully consistent with best practice.

Condition parameters are generally within normal range for best practice, especially for stations’ assets such as transformers and breakers where testing and inspection data are available.

Age continues to be included as a significant parameter in many of the HI formulations. In our view, this is a debatable practice. It is by no means a fatal flaw. We do see age as being a useful parameter:

- If no condition data are available then age is the proxy for condition, though generally a poor proxy;
- Age is a minor parameter when better data are available;
- HI methodology is focused on “effective age” (when properly done), so factoring in calendar age is necessary at some point; and
- Where test data show continued strong correlation between age and condition, many better performing utilities would reduce the costs of testing for that particular asset and rely more heavily on age.

Within the Horizon ACA, for some assets age is the only parameter, e.g. concrete poles. While we accept that this is the proxy for condition we do not believe that it is appropriate for it to be considered as
a Health Index. Doing so could mask findings in a way that would limit the interpretation of the results and potentially skew spending or investment decisions.

Horizon considers a Health Index “valid” as long as age data is available. In our view Horizon does not apply a best practice threshold for data availability in determining if it has a valid Health Index. This is not consistent with best practice. This is reasonable for the effective age calculation and as a proxy for condition, but not as a Health Index. Best practice utilities apply a level of rigour to determining the point at which they have a valid HI and differentiate between valid and incomplete HI and condition assessments. This supports their process in ensuring that the impacts of incomplete data are transparent and that making comparisons between assets with valid HI and those without valid HI are done with full understanding of the variation in accuracy. This ensures that assessments based on incomplete, not valid, HI are not biasing the investment decisions.

CAPITAL INVESTMENT PLANS

1. Assumptions and Approach

   Life-cycle optimization of asset investments is the stated objective of Horizon’s Capital Investment Plans. For Horizon, ACA is the primary driver for renewal investments. The ACA feeds the renewal plans via the “flagged for action” plan. Horizon is confident in the ACA approach in part due to a review of the ACA by third party (KPMG), who reviewed the plan and input parameters and identified adjustments and insights for Horizon based on its knowledge and experience with other utilities and with ACA.

   Specific projects are identified through planning processes and scored for prioritization on a 1-5 according to drivers: safety, security, customer impact, regulatory/statutory and environmental. Horizon acknowledges that its prioritization process is limited and does not lend itself to the level of optimization that it has targeted. Horizon appears to have a sound understanding of the gaps between its current approach and where it believes it needs to be with respect to best practice optimization. Horizon is working to incorporate an updated value and risk model, and has begun investigating decision support tools such as Copperleaf, that it believes would enable it to improve the ability to test its inputs and assumptions. Horizon does not currently undertake routine scenario analysis or stress testing on its drivers. Nor does it appear to test the impact of HI parameters on the assets that would be flagged for action and thus be candidates for inclusion in the investment or renewal plans.

   Horizon prepares business cases supporting projects and investments. These are used as a primary in the prioritization/scoring and appear to be consistent with OEB requirements.

2. ACA Translation

   In the development of the capital investment plans, it appears that “Flagged for action” assets are a significant driver of the renewal plans as well as the overall spending levels. We believe that Horizon is making renewal investment decisions based on both proactive and reactive spending expectations.

   For those assets where the spending is proactive, the cumulative probability of failure (based on Health Index) times criticality index is the basis for identifying assets in need of replacement. For some proactive assets, the criticality is assumed to be the same for each asset, which is effectively a spending program based on health only.

   For those assets where the spending is reactive, replacement rates are based on estimated probability of failure per ACA. We note that these failure rates are not calibrated to recent experience and thus may not be as accurate a predictor of spending needs as possible.

   ACA results guide Horizon to areas of high risk. Horizon does not simply take the ACA results and convert them to investment plans. Horizon reviews the ACA results, particularly with respect to risk, and identifies assets that represent a risk and regions within their system with concentrations of mid-to-high probability of failure assets, or sub-classes of assets. This is a highly useful and best practice
approach to interpretation of the ACA and generates insight for incorporation into optimal investment plans.

We observed specific cases where Horizon has been taking the ACA results and applying insight and engineering judgment. For instance, the cable replacement amount contained in the investment plan is based on the ACA results. The location of the investment is based on system performance and other factors. Horizon has used the ACA results and its knowledge and insight to focus on Hamilton Mountain where outage consequences are highest.

In a similar vein:

- Horizon does not simply apply the ACA results to determine spending. Horizon takes the ACA results and explores alternative interventions, e.g. refurbishment. It uses the ACA results to guide this work at the planning stage.
- Proactive programs for specific assets (station transformers, breakers) are evaluated according to long-range plans for the stations. For instance, 4kV/8kV stations that are slated for retirement are not good candidates for large capital investment, regardless of the ACA results.

Spending programs, many of which have been underway for years, are attributed to ACA recommendations. For instance, refurbishment of 4kV/8kV overhead is considered part of the wood pole renewal program. This use of the ACA to help guide investment and find opportunities for economies of scale in matching short term and mid-term system needs result in lower overall spending for a given system performance level.

3. Constraint Analysis

Within Horizon we did not see much evidence that constraints were resulting in potential risks to system performance or the ability to undertake renewal programs. As with most utilities there is a category of spending that is “mandatory”. These must-do projects are identified as such in the prioritization process. Horizon appears to have applied clear standards and solid rigour to defining and screening mandatory spending. This is an issue for many utilities. Loose definitions of mandatory result in large percentages of their overall spending being deemed mandatory. This is not the case with Horizon and its mandatory spending levels are in keeping with what we would expect to see for Ontario. Horizon’s application of the mandatory filtering criteria is a best practice approach.

In our discussions with Horizon, and our review of the investment programs, it does not appear that renewal programs are compromised by lack of funding or resources except during the initial ramp-up, Horizon is fully aware of constraints on resource and capital in the near term, as well as the need to manage rate impacts to customers, which is the purpose of the ramp-up period.

Horizon does understand both the financial constraints that it has as a business as well as resource constraints though neither has been a factor that has compromised the decisions that it otherwise would have made.

4. Reasonability Testing

Horizon has used the ACA to validate its decisions regarding plans for renewal. Many of these plans were longer term plans that were developed prior to 2012. Horizon’s SMEs review the ACA results and, as discussed previously, use their knowledge and expertise to interpret the results and develop plans that are informed by the ACA but not dictated by it. Horizon also engages in informal discussions with peer utilities to check and validate what it is seeing from its ACA as compared to the experience of other utilities.

Horizon has recognized that the current method of undertaking the ACA does not fully support an assessment of the ramp-up period to manage resources and rates: ACA does not directly support “smoothing” or prioritization when spending needs exceed resources, whereas some approaches to ACA, with more advanced cost/benefit assessment, support prioritization and smoothing directly. The SMEs are utilized to support this translation and apply reasonability. Future improvements in the
ACA should be geared toward supporting results that are more closely aligned with the SME knowledge and insights.

There are some areas where Horizon should look to improve its ACA process in the short term. Of higher importance is the need to test the sensitivity to changed assumptions in ACA, especially failure probability and criticality. This will help Horizon identify areas where better data is more critical and it will enable Horizon to better scenario test its ACA results as it finds changes in failure rates from those predicted. A second area for focus would be the reconciliation of the ACA predictions against recent historical results as well as future trends. A third area that does not appear to be considered in the ACA or the translation into the investment plan is the estimation or quantification of cost/benefit from the customers’ perspective. Is this spending really worth it? To some degree this is handled in the assessment of the impact of the investment plans on rates but there is no method for assessing the impact of the individual investment other than its cost impact in the overall investment plan.

5. Optimal Investment Profile

As discussed above, Horizon’s ability to identify optimal investment profiles has been improving over the last several years. The process that it uses for ranking and prioritizing investments is common in the industry and is a natural step in the evolution towards true optimization based on value and risk.

RESULTING EXPENDITURE LEVELS

Review of the Horizon ACA reveals the need to spend nearly $700 million in renewal over 20 years. Planned investments will match this level after an initial ramp-up period. There is a large ramp up in cable remediation and replacement from about $1 million/year to about $10 million/year. There are large expenditures indicated for line transformers and wood poles. The assets are currently treated as largely run-to-failure (even if failure means identified as “failed” in an inspection). These programs should be calibrated to recent experience; this process is underway internally.

Horizon has estimated the cost premium for reactive work relative to planned, and is factoring it into decision making. This is consistent with best practice.

BEST PRACTICE ASSESSMENT

One of the requests made of VAI was to undertake an assessment of each of the LDCs against best practices in the areas of ACA (HI) and capital investment planning. The following table provides a summary of the assessments that we have made for Horizon. In undertaking the assessment we have used a set of criteria that we believe represent best practice performance in the areas of ACA and investment optimization. The criterion and their definitions as well as our observations of Horizon against each is included in the table below.

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<td>Determining End of Life</td>
<td>Proactive assets (stations): end of life is determined based on estimated failure probability and subjective (though consistent) measures of consequence. Cost of intervention is not considered.</td>
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<td>Proactive assets (lines): end of life is determined based on estimated failure probability and a single assumed criticality applied to each asset. Cost of intervention is not considered.</td>
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<td>Reactive assets: assumed run-to-failure due to perceived low criticality.</td>
</tr>
<tr>
<td></td>
<td>No business cases back-up these strategies.</td>
</tr>
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### CRITERION DEFINITION (CONT’D)  
### VAI ASSESSMENT: HORIZON UTILITIES (CONT’D)

<p>| <strong>Business Case</strong> | Spending recommendations have an accompanying business case that summarizes the problem statement, compares alternatives, and makes a recommendation. All costs and benefits are quantified from the customers' perspective; alternatives including the do-nothing alternative are considered; assumptions are stated explicitly and quantitatively. | Business cases are based on OEB filing requirements and the prioritization scoring method used by Horizon. Benefits of project are scored in this way, but are not explicitly compared with costs. Do-nothing is the unstated alternative. Other alternatives may be described but not evaluated for comparison. Benefits and risks are based on customer values (e.g., safety, reliability, environmental). |
| <strong>Long-Range Projections</strong> | Aging asset populations include a projection of future spending needs based on expected future degradation and risk. | Long-range projections are provided in the ACA, based on the assumed replacement strategies for each asset class. These are incorporated into the long-range spending plan. |
| <strong>Prioritization/Optimization Across Programs</strong> | Spending on replacement, refurbishment, maintenance, and other options are directly compared in equal terms to optimize spending plans and to prioritize across programs. Capital and OMA expenditures are optimized in the same process using the same or comparable criteria. | Prioritization process compares spending across assets in equal terms based on the standard scoring scale. The ACA includes an estimate of risk for some “proactive” asset classes, where risk is probability of failure times expected consequence of failure. The prioritization model also includes an assessment of risk, but the assumptions do not appear to be consistent. Ideally, the way a spending option is scored in ACA should translate directly into the business case and the prioritization model. This will simplify scoring and help ensure “apples-to-apples” comparisons. |
| <strong>Use of Subject Matter Experts (SME)</strong> | Tacit knowledge of subject-matter experts is incorporated into the assessment process. Attention is focused on their areas of expertise (e.g. how best to assess condition) as opposed to complex questions outside it (e.g. how many transformers should we replace each year). SME input is documented explicitly for review and improvement over time. | Internal SMEs review, modify, and approve the Health Index formulations. Their expertise is the basis for evaluating alternative interventions. Subject-matter expertise should be applied to failure probability estimates, consequence costs, and other technical input assumptions in the ACA. |
| <strong>Risk Assessment</strong> | Asset risk is quantified in terms of actual failure probability and expected consequence cost of failure in terms that can be used in business cases and the budgeting process. Risk is included in business cases both as a benefit of spending (e.g., avoided risk) and as part of the cost of the work (e.g., risk of cost overrun). | Failure probability is an estimate of actual failure, but has not been calibrated to even recent failure history. Consequences of failure are quantified for a few asset classes. They are not based on actual customer costs or calibrated with the prioritization model. Avoided risk is implicitly included in the business case. |</p>
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<tr>
<td><strong>Failure Probability</strong></td>
<td>Definition of “failure” is not clearly stated. It appears to be related to end of life, since it is driving reactive replacement programs. However, assets such as breakers and direct-buried cable can fail multiple times without being replaced. It is not clear whether this has been considered. Failure probability is estimated based on effective age, which incorporates calendar age and condition parameters.</td>
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<td>The meaning of failure is clearly defined and consistently applied (e.g. end-of-life failure events that require replacement). The likelihood of failure is determined based on condition, age, and historical data.</td>
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<tr>
<td><strong>Consequences of Failure (Asset Criticality)</strong></td>
<td>Consequences of failure are not monetized or expressed in terms that can be used in decision-making outside the ACA, e.g., prioritization or business cases. Costs are customer focused, though implicitly. Multiple failure scenarios are not considered.</td>
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<td>Failure consequences are monetized and related directly back to the customer as an outage cost or willingness-to-pay social cost. Consequence costs are intended to reflect the perceived cost to the customer. For example, how much would a ratepayer be willing to pay on a monthly basis to reduce or avoid power outage events? Where appropriate, multiple failure scenarios are considered and weighted according to their relative likelihoods.</td>
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**Processes Documentation**

Work flow processes are documented for significant tasks within the organization. The roles and responsibilities of each individual are documented and reviewed on a regular basis.

The required flow of data to support asset management is documented. This includes data collection and storage, data requirements for program development, and data requirements for project justification and prioritization in the budgeting process.

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<td>Since the ACA is largely outsourced to a consultant, there is less need for detailed documentation of workflow. Horizon provides a review of assumptions and data needed to support the analysis.</td>
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**OTHER OBSERVATIONS RELATED TO ASSET MANAGEMENT**

In our review of the Horizon materials and through or discussions with Horizon personnel we were able to make additional observations relative to the Asset Management organization performance. Horizon exhibits many characteristics of best practice companies. While we would suggest that Horizon is not yet fully at best practice level it is well ahead of a large number of the utilities in the industry and above average in terms of its work in ACA and investment optimization. We note that there are numerous clear indicators that continual improvement is underway and well entrenched in the organization, another leading characteristic.

The areas that we observe would be of greatest value in supporting Horizon’s move toward true best practice include:

- Incorporation of substantive business cases;
- Routine calibration/sensitivity analysis in ACA;
- Creating a rigorous process for computing asset criticality;
- Bringing the ACA work into the organization (relying on external consultants for support or audit as needed)
  - strengthens the skills and insight in the organization,
  - improves the ability to stress test and scenario test criteria; and
- Evolve from prioritization process for investments to a more robust multivariate optimization approach
  - for all capital spend,
  - for all OMA spend.

This should not be viewed as a criticism of Horizon or an implication that it is not performing well. In fact, its work over the last several years and the adoption of the ACA approach has been accepted by OEB to-date, with minor reductions required in the most recent rate case, even within a filing that included substantial increase in renewal request.
VAI consultants (Darin Johnson and Stewart Ramsay) met in person with Hydro One Brampton (HOBNI) on May 21 to review the ACA and DSP materials that HOBNI has provided, and to address specific questions VAI had regarding the ACA process, methodology and its use in developing the capital investment plans.

For HOBNI, the meeting was attended by:

- Tom Wasik, Director of Asset Management & Engineering
- Wolf Schaefer, Manager, Project & Asset Management
- Rolando Mena, Supervisor, Asset Management
- Jessica Davis, Restructuring Secretariat Observer

The meeting was productive and provided VAI with greater understanding of the process, the data elements used, the respective roles of different parts of the HOBNI organization in the development of the ACA, and a more complete understanding of how the ACA results are used in the identification and development of capital investments.

Our observations and assessments are summarized, by topic, in the following paragraphs.

**ACA**

2. **Asset Categories**

HOBNI contracts with an external consultant for the development of the ACA. HOBNI provides the input data, but relies on the external consultant for the calculations and the methodology.

The determination of Asset Categories was done in collaboration with the consultant based on the combined experience of HOBNI and the consultant, and its experience regarding assets that have significant financial or reliability impact on the system. HOBNI’s ACA is focused on the Asset Categories identified in the table to the right.

Some assets are subdivided based on significant variation in the end of life drivers, e.g. circuit breakers are divided into air and oil for HI purposes; cable is split into XLPE, PILC, secondary. However, this stratification is limited.

In industry terms, HOBNI assesses a large number of assets in its ACA. The level of rigour and detail tends to drop off after the most critical assets. This is common among utilities who are starting the ACA process. We expect that HOBNI will continue to add to the rigour and data collection. HOBNI appears to see additional value in further separation based on the performance of subsets of assets in some of the large asset categories.

Protective relays and communication systems are not evaluated in HOBNI’s ACA. This is inconsistent with better performing utilities as these assets are often high-value, high risk impact assets.

a. **Impact on renewal investment plans**

For HOBNI, as is the case with most utilities, the somewhat limited detailed stratification to identify specific problem types or highly critical assets, makes planning difficult. It tends to limit the ability to undertake more meaningful “bottoms-up” cost assessments which leads to a top-down spending cap approach to estimating spending need. The limited ability to do
more detailed and predictable scenarios on asset failure related spending can become problematic. HOBNI has done good work in its ACA and is clearly leveraging the value of that work in the development and influence of its investment plans. We believe that further work in this area on both granularity of assets and asset HI data will enable HOBNI to increase the predictability and accuracy of its asset failures as well as accurately predict impacts on system performance resulting from any given investment or renewal plan.

HOBNI does not undertake a routine review of ACA results against recent performance by asset category to validate the results of the ACA. This is inconsistent with best practice. HOBNI has acknowledged the value of this on certain asset types, particularly where data is limited.

There is the potential that the results of the ACA, to the extent they are not fully accurate are pointing to somewhat less optimal renewal investment profiles. We recognize that this is also a common characteristic of utilities that have embarked on the HI and ACA path. HOBNI’s ACA results and the impact that they have on the investment plans are significantly better than the results it was able to produce in prior years and it continues to improve the quality of the ACA and its ability to use the results to create well informed investment programs.

3. Condition Parameters

The condition parameters have been proposed by the external consultant and are reviewed and approved by SMEs inside HOBNI. The condition data is collected by HOBNI by its personnel and by its testing contractors. HOBNI screens and cleans up the data and provides it to the external contractor for use in the ACA.

The condition parameters employed by HOBNI are sparse relative to the range for best practice. This is especially true for station assets such as transformers and breakers where testing and inspection data are usually readily available.

The breaker formulation is not consistent with best practice. HOBNI’s contractor is using contact resistance as the only factor besides age. We understand the argument that contact resistance is a proxy for the number and type of operations, and we acknowledge that in the absence of historical data on operations that it is a valuable measure. We do believe that HOBNI should explore other measures (such as timing tests) in addition to contact resistance that would help avoid the potential for end of life purely based on contact resistance.

HOBNI employs several aggressive de-rating factors that might be worth reviewing, e.g. 0.4 multiplier on HI for obsolete transformers, and for PCB for line transformers. The low numbers tend to move this type of equipment out of the system ahead of its true end of life. This is often a practice in utilities that have determined that the risks of failure of obsolete equipment or of modest concentration PCB transformers are higher than the cost of a premature replacement. We do not see the business cases or analysis that supports these decisions. We are not implying that these decisions are wrong. Many utilities have undertaken the analysis to justify such decisions. In the time available for our review we did not see that analysis.

Age continues to be included as a significant parameter in several of the HOBNI HI formulations. In our view, this is a debatable practice. It is by no means a fatal flaw. We do see age as being a useful parameter:

- If no condition data are available, then age is the proxy for condition, though generally a poor proxy;
- age is a minor parameter when better data are available;
- HI methodology is focused on “effective age” (when properly done), so factoring in calendar age is necessary at some point; and
• Where test data shows continued strong correlation between age and condition, many better performing utilities would reduce the costs of testing for that particular asset and rely more heavily on age.

Based on the methodology used by the external consultant, in the HOBNI ACA, a Health Index is considered “valid” as long as age data are available. In our view HOBNI and its consultant are not applying a best practice threshold for data availability in determining if it has a valid Health Index. It is reasonable for the effective age calculation and as a proxy for condition, but not as a Health Index. Best Practice utilities apply a level of rigour to determining the point at which they have a valid HI and differentiate between valid and incomplete HI and condition assessments. This supports their process in ensuring that the impacts of incomplete data are transparent, that making comparisons between assets with valid HI and those without valid HI are done with full understanding of the variation in accuracy. This ensures that assessments based on incomplete, not valid, HI are not tilting the investment decisions in an inappropriate direction either towards or away from the true need.

Using age is reasonable for the effective age calculation, but questionable as a Health Index.

CAPITAL INVESTMENT PLANS

1. Assumptions and Approach

Life-cycle optimization is the stated objective for HOBNI investment plans. HOBNI has a documented process for identifying and evaluating spending needs, optimizing, and budgeting. ACA is one input for defining needs rather than identifying investment levels. Using ACA as a driver of defining needs is consistent with best practice.

ACA generated “needs” (i.e. “flagged for action”) are evaluated for technical alternatives, including refurbishment, reconfiguration and replacement.

The output of the ACA is subject to a business case process, applying the same scoring of risk and benefits used in the corporate prioritization/budgeting process. Again this is consistent with best practice.

2. ACA Translation

“Flagged for action” assets are the main source of spending for asset replacement.

For those assets where the spending is proactive, the cumulative probability of failure (based on Health Index) times criticality index is the basis for identifying assets in need of replacement. For some proactive assets, the criticality is assumed to be the same for each asset, which is effectively a spending program based on health only.

For those assets where the spending is reactive, replacement rates are based on estimated probability of failure per ACA; we note that the failure rates are not calibrated to recent experience and thus may not be as accurate a predictor of spending needs as possible.

HOBNI’s planning and other engineering functions are responsible for identifying possible projects for evaluation based on the spending levels projected in the ACA. These spending recommendations are smoothed over time and adjusted based on known programs, e.g. voltage conversion. This results in an overall lower cost for level of system performance.

Alternative interventions, e.g. refurbishment, are considered at the technical alternatives stage. Some alternatives have been accepted generally, such as cable injection.

Major projects such as station transformer, wood pole, and cable replacement are budgeted as programs in the DSP.
3. **Constraint Analysis**

Must-do projects are identified at the “needs” stage. HOBNI applies a clear set of standards to define mandatory work, to eliminate the potential for non-mandatory work being misclassified. Reasonable judgment is applied, e.g. safety projects that address a known problem are must-do. Whereas safety related projects based on normal risk of failure are evaluated through the business case/prioritization process. This is consistent with best practice utilities.

Renewal programs are not compromised by lack of funding or resources except in smoothing the initial spikes, so constraints have not apparently played a significant role in planning. HOBNI's smoothing appears to be an implicit understanding of the need to manage within an expected ceiling based on ensuring stable rates to customers.

HOBNI has not found itself constrained by its board or by the OEB in obtaining capital to undertake the projects and programs that it believes are essential to the business.

4. **Reasonability Testing**

As an integral part of the development of the ACA and capital investment profile, HOBNI undertakes several reasonability tests. HOBNI goes through a subjective review by AM team and SMEs in the organization. This happens at various stages in the overall process. This ensures that the results of each of the steps in the process are matched with the knowledge and experience of the people that understand the system the best.

HOBNI engages in informal discussions with peer utilities to gain insights as well as test their findings against those of other utilities in similar circumstances.

HOBNI prepares its plans such that it understands the resource requirements and ramp up times.

HOBNI also examines proposed programs to identify how they can be improved based on experience of the programs already underway. This provides further clarity around actual cost and schedule that can be used to validate the value of the proposed plans.

We did note that HOBNI does not undertake sensitivity analysis to changed assumptions in ACA, especially failure probability and criticality. We attribute this largely to the fact that the ACA is conducted outside of HOBNI and thus running such analysis is potentially costly and cumbersome. We believe that this is an area that would be valuable for HOBNI to explore. It already has several best practices firmly embedded in its processes, this type of analysis would tend to strengthen the knowledge and insights of the organization.

We did not see much evidence that HOBNI has worked to quantify cost/ benefit from the customers’ perspective, i.e. is this spending really worth it? HOBNI’s business cases are detailed and so we recognize that the business cases could serve a reasonable approximation, if HOBNI ensures that customer cost is a valid parameter.

5. **Optimal Investment Profile**

HOBNI does an optimization of its capital investment program. HOBNI explicitly examines and scores the value of the investment across the range of corporate objectives. It also explicitly scores the investment with respect to the risk to the business (including personnel and public) if the investment is not undertaken. Our understanding is that HOBNI includes all capital expenditures, across all business units in the organization. The inclusion of all capital (e.g. facilities, fleet, furnishings, IT, line assets, station assets, etc.) is a leading practice and ensures that all capital is directed towards addressing the highest value or highest risk needs.

HOBNI has not yet applied the optimization process to its OMA expenditures. We believe that the process and standards already in place would support such an OMA optimization.
HOBNI is investigating new decision support tools that would enable it to integrate the ACA results into the optimization analysis. This would be a leading practice.

RESULTING EXPENDITURE LEVELS

In our review of HOBNI’s materials we did not see a clear comparison of renewal spending projection to the totals from ACA. We did note that renewal spending has increased since about 2009, which is when AM processes were introduced. The spending levels have risen from $4 million in 2009 to nearly $9 million in the 2016 test year.

The wood poles replacement program tops out at 280 per year. This represents a replacement rate of about three percent of the population.

In our discussions with HOBNI we pointed out a concern we have with the methodology used by the ACA consultant with respect to cables. The assumed failure curve for XLPE primary cable has a very steep elbow: more than half of all failures are expected to occur in a five-year window. This effectively results in an age-based program with a large backlog (as shown in the ACA Figure 11-1). We believe that the backlog may be exaggerated by the de-rating factor for recent failures: a single fault in a 100m cable segment would translate to over 1000 faults/100 km and a de-rate factor of 0.6. If this is applied as described, it would push any segment with a fault into the “flagged for action” category. Essentially a fault on a short segment is a death sentence for that segment, which is not consistent with industry best practice, nor with HOBNI’s intent. We understand that HOBNI is moving from faults per 100km to faults per segment for its next ACA. We believe that this will result in a significant shift in the assumed failure curve for this type of cable.

BEST PRACTICE ASSESSMENT

One of the requests made of VAI was to undertake an assessment of each of the LDCs against best practices in the areas of ACA (HI) and capital investment planning. The following table provides a summary of the assessments that we have made for HOBNI. In undertaking the assessment we have used a set of criteria that we believe represent best practice performance in the areas of ACA and investment optimization. The criterion and their definitions as well as our observations of HOBNI against each is included in the table below.

<table>
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<tr>
<th>CRITERION DEFINITION</th>
<th>VAI ASSESSMENT: HYDRO ONE BRAMPTON</th>
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| Determining End of Life | Proactive assets (station transformers and breakers): end of life is determined based on estimated failure probability and subjective (though consistent) measures of consequence. Cost of intervention is not considered.  
Proactive assets (some lines assets): end of life is determined based on estimated failure probability and a single assumed criticality applied to each asset. Cost of intervention is not considered.  
Reactive assets: assumed run-to-failure due to perceived low criticality.  
No business case back-up for these strategies. |

Determined according to a systematic approach, balancing the cost of continued operation against the cost of replacement to minimize life-cycle cost of ownership. Other interventions, e.g. refurbishment, are considered.
**CRITERION DEFINITION (CONT’D)** | **VAI ASSESSMENT: HYDRO ONE BRAMPTON (CONT’D)**

**Business Case**<br>Spending recommendations have an accompanying business case that summarizes the problem statement, compares alternatives, and makes a recommendation. All costs and benefits are quantified from the customers’ perspective; alternatives including the do-nothing alternative are considered; assumptions are stated explicitly and quantitatively.<br><br>Have a business case process for scoring benefits and risks of proposed projects. Large-scale projects such as cable replacement are evaluated as a single line-item. Do-nothing is the unstated alternative. Other alternatives are considered in the technical alternatives step, but are not assessed quantitatively. Benefits and risks are based on customer values (e.g., safety, reliability, environmental).

**Long-Range Projections**<br>Aging asset populations include a projection of future spending needs based on expected future degradation and risk.<br><br>Long-range projections are provided in the ACA, based on the assumed replacement strategies for each asset class. These are treated as “needs” for evaluation in the asset management process.

**Prioritization/ Optimization Across Programs**<br>Spending on replacement, refurbishment, maintenance, and other options are directly compared in equal terms to optimize spending plans and to prioritize across programs. Capital and OMA expenditures are optimized in the same process using the same or comparable criteria.<br><br>Optimization process compares spending across assets in equal terms based on the standard scoring scale. All capital of all types (asset and non-asset) is included in the optimization. The ACA includes an estimate of risk for some “proactive” asset classes, where risk is probability of failure times expected consequence of failure. The prioritization model also includes an assessment of risk, but the assumptions do not appear to be consistent. Ideally, the way a spending option is scored in ACA should translate directly into the business case and the prioritization model. This will simplify scoring and help ensure “apples-to-apples” comparisons.

**Use of Subject Matter Experts (SMEs)**<br>Tacit knowledge of subject-matter experts is incorporated into the assessment process. Attention is focused on their areas of expertise (e.g. how best to assess condition) as opposed to complex questions outside it (e.g. how many transformers should we replace each year). SME input is documented explicitly for review and improvement over time.<br><br>Internal SMEs review, modify, and approve the Health Index formulations. They review and select intervention alternatives and create rational programs from the assessed needs. Subject-matter expertise should be applied to failure probability estimates, consequence costs, and other technical input assumptions in the ACA.

**Risk Assessment**<br>Asset risk is quantified in terms of actual failure probability and expected consequence cost of failure in terms that can be used in business cases and the budgeting process. Risk is included in business cases both as a benefit of spending (e.g. avoided risk) and as part of the cost of the work (e.g. risk of cost overrun).<br><br>Failure probability is an estimate of actual failure, but has not been calibrated to even recent failure history. Consequences of failure are quantified for a few asset classes. They are not based on actual customer costs or calibrated with the prioritization model. Avoided risk is implicitly included in the business case.
### Condition Assessment

Asset conditions are assessed relative to end-of-life failure criteria (i.e. Health Index). Health Index includes relevant parameters for predicting failure based on known degradation processes, and excludes other factors such as those related to criticality or obsolescence. Age is not included as a condition criterion.

### Failure Probability

The meaning of failure is clearly defined and consistently applied (e.g. end-of-life failure events that require replacement). The likelihood of failure is determined based on condition, age, and historical data.

### Consequences of Failure (Asset Criticality)

Failure consequences are monetized and related directly back to the customer as an outage cost or willingness-to-pay social cost. Consequence costs are intended to reflect the perceived cost to the customer. For example, how much would a ratepayer be willing to pay on a monthly basis to reduce or avoid power outage events?Where appropriate, multiple failure scenarios are considered and weighted according to their relative likelihoods.

### Processes Documentation

Work flow processes are documented for significant tasks within the organization. The roles and responsibilities of each individual are documented and reviewed on a regular basis.

The required flow of data to support asset management is documented. This includes data collection and storage, data requirements for program development, and data requirements for project justification and prioritization in the budgeting process.

### VAI Assessment: Hydro One Brampton (Cont’d)

Health Indices are based on major degradation processes and end of life criteria. The formulations are generally within the range of best practice, although recent improvements in the industry (e.g. multiplicative formulation) have not been applied.

The multiplicative approach to health indexing is in contrast to the additive approach used by all four utilities in this review. It is a recent industry innovation wherein condition parameters are multiplied together rather than added. It avoids some of the common problems: “masking,” where a bad test result is hidden amid several good ones, and validity, where there are not enough data available to calculate a valid health index.

Relevant parameters are included except where data are known not to be available.

Age is included in all formulations. This is mitigated by the focus on effective age rather than Health Index itself as the end output.

Factors related to obsolescence or consequences are generally excluded from the formulations.

Definition of “failure” is not clearly stated, although HOBNI experts are clear that they mean “end of life” as opposed to minor, repairable failures.

Failure probability is estimated based on effective age, which incorporates calendar age and condition parameters.

Consequences of failure are not monetized or expressed in terms that can be used in decision-making outside the ACA, e.g., prioritization or business cases.

Costs are customer focused, though implicitly.

Effect of obsolescence is factored into criticality assessments, as it should be.

Multiple failure scenarios are not considered.

HOBNI has an Asset Management process document that they use to guide the entire decision-making process. ACA is an input for identifying needs.

Data requirements are documented in the ACA, e.g. test and inspection results for calculating health.

Matching of projects to the recommended/projected spending levels appears to require significant judgment and is difficult to systematize.
OTHER OBSERVATIONS RELATIVE TO ASSET MANAGEMENT

In many instances we see that HOBNI is near the front of best practice, and the AM team views that it is still working and still needs to improve other aspects of its processes.

HOBNI has a clear focus on optimizing the overall capital to ensure value to customers, as opposed to a more technical approach focused on the assets. Continuous improvement of process and methodologies is clearly underway and a standard for HOBNI's AM organization.

HOBNI expects to be able to begin predicting reliability impacts from its renewal projects.

HOBNI is also expecting to introduce the use of business cases for maintenance programs. HOBNI has already performed an effectiveness evaluation of maintenance practices which resulted in expanded IR inspection. This is advanced and a reinforcement of the commitment to reaching and maintaining best performance.

HOBNI's current approach has been accepted by OEB to-date, and spending requests for renewal based on ACA have been approved.

HOBNI does have areas that it should focus on improving. These include:

• Improvements in its business case methodology;
• Calibration and sensitivity analysis of ACA results with recent actual system performance; and
• Development of a more rigorous process for computing asset criticality.
Enersource

VAI consultants (Darin Johnson and Stewart Ramsay) met in person with Enersource on May 21 to review the ACA and DSP materials that Enersource has provided, and to address specific questions VAI had regarding the ACA process, methodology and its use in developing the capital investment plans.

For Enersource, the meeting was attended by:

- Alykhan Premji, Reliability Engineer
- Chris Master, Capital Manager
- Chris Hudson, VP Asset Operations
- Branko Boras, Manager, Asset Planning & Analysis

The meeting was productive and provided VAI with greater clarity around the process, the data elements used, the respective roles of different parts of the Enersource organization in the development of the ACA, and most importantly an understanding of how the ACA results are used in the identification and development of capital investments.

Our observations and assessments are summarized by topic in the following paragraphs.

ACA

1. Asset Categories

Enersource uses an external consultant for the development of the ACA. Enersource provides the input data, but relies heavily on the external consultant for the calculations and the methodology.

The determination of Asset Categories was done in collaboration with the consultant based on the combined experience of Enersource and the consultant, and its experience regarding assets that have significant financial or reliability impact on the system. Enersource’s ACA is focused on the Asset Categories identified in the table to the right.

Assets are generally well subdivided for Health Indexing purposes; some “bad actors” have been identified by manufacturer, e.g. certain types of breakers and line transformers. These specific types of equipment have been validated with specific failure modes and risks that warrant specific treatment in the ACA and risk prioritization.

Further breakdown may be beneficial to Enersource in enabling better identification of opportunities to manage cost and risk. These include: tap-changers, type-U bushings, etc. These breakdowns should be based on actual data wherever possible.

In industry terms, a large number of assets were assessed in Enersource’s ACA, although the level of rigour and detail drops off after the most critical assets. This is common among utilities who are starting the ACA process. We expect that Enersource will continue to add to the rigour and data collection. It is clear that there is funding in their plans to accomplish that objective and the plans for specific data capture and analysis appear to be well defined.
Protective relays and communication systems are not evaluated in Enersource’s ACA. This is inconsistent with better performing utilities as these assets are often high-value, high risk impact assets.

a. Impact on renewal investment plans

For most utilities, and in our view this holds for Enersource, the somewhat limited detailed stratification to identify specific problem types or highly critical assets, makes planning difficult. It tends to limit the ability to undertake more meaningful “bottoms up” cost assessments which leads to a top-down spending cap approach to estimating spending need. The limited ability to do more detailed and predictable scenarios on asset failure related spending can become problematic. Enersource has done good work in its ACA and it is clearly leveraging the value of that work in the development and influence of its investment plans. It is deliberate in its efforts to improve the level and quality of the data that it collects and uses in the ACA. We believe that further work in this area on both granularity of assets and asset HI data will enable Enersource to increase the predictability and accuracy of its asset failures as well as accurately predict impacts on system performance resulting from any given investment or renewal plan. This would tend to improve the quality and transparency of the renewal and investment plans overall and increase credibility with the OEB and interveners in rate proceedings.

Enersource does not undertake a routine review of ACA results against recent performance by asset category to validate the results of the ACA. This is inconsistent with best practice. We recognize that it is relatively new to this process and so is continuing to work to improve the process.

Enersource has recognized the need for this on certain asset types, particularly where data is limited. It has moved deliberately to increase its efforts in these areas. Enersource has also taken a best practice step of working to identify the specific data needs and the potential value of the data before it is collected. It has also moved to handheld data collection tools that automatically apply standards for data capture, another best practice.

There is the potential that the results of the ACA, to the extent they are not fully accurate are pointing to somewhat less optimal renewal investment profiles. We recognize that this is also a common characteristic of utilities that have embarked on the HI and ACA path. Enersource’s ACA results and the impact that they have on the investment plans are significantly better than the results it was able to produce prior to 2012.

2. Condition Parameters

The condition parameters used in the ACA have been proposed by the external consultant and reviewed and approved by senior level SMEs inside Enersource. It may be beneficial to extend involvement in these reviews to field personnel. This would provide greater insights for the ACA and for the field personnel and foster even greater buy-in for data collection and strategy.

The condition data is collected and provided by Enersource to the consultant as described above.

The condition parameters are generally within normal range for best practice, especially for stations’ assets such as transformers and breakers where testing and inspection data are available. Enersource is expanding the formulations. We expect that, over time, as their data collection, testing and inspection processes continue to mature, Enersource will see continued improvement in the accuracy and insight of the ACA results.

Enersource’s consultant applies a data availability indicator (DAI) in its reporting. This DAI can be misleading. If the data for an asset type is only age (which provides only minimal value in HI and ACA) then having all of the age data results in a 100% DAI. On the other hand, for assets where Enersource has identified 10 parameters that materially impact condition and end of life, having only
80% of the data results in a DAI of 80%. In our view the 80% data would produce far more meaningful results than 100% of the age data. If Enersource desires to retain a DAI, we believe that weighting the data elements by their relative value in producing an HI would be prudent. As it stands the DAI is merely a measure of completion.

Age continues to be included as a significant parameter in many of the Enersource HI formulations. In our view, this is a debatable practice. It is by no means a fatal flaw. We do see age as being a useful parameter:

- If no condition data are available, then age is the proxy for condition, though generally a poor proxy;
- Age is a minor parameter when better data are available;
- HI methodology is focused on “effective age” (when properly done), so factoring in calendar age is necessary at some point; and
- Where test data shows continued strong correlation between age and condition, many better performing utilities would reduce the cost of testing for that particular asset and rely more heavily on age.

Within the Enersource ACA, for some assets age is the only parameter, e.g. poles. While we accept that this is the proxy for condition we do not believe that it is appropriate for it to be considered as a Health Index. Doing so could mask findings in a way that would limit the interpretation of the results and potentially skew spending or investment decisions. Enersource is beginning a pole testing program (hammer test only); industry normal practice is more extensive testing to determine remaining strength. Enersource may wish to work with other utilities in the province to gain insights into the cost/benefit of more extensive pole testing.

For Enersource, based on the methodology used by the external consultant, a Health Index is considered “valid” as long as age data are available. In our view Enersource is not applying a best practice threshold for data availability in determining if it has a valid Health Index. It is reasonable for the effective age calculation and as a proxy for condition, but not as a Health Index. Best practice utilities apply a level of rigour to determining the point at which they have a valid HI and differentiate between valid and incomplete HI and condition assessments. This supports their process in ensuring that the impacts of incomplete data are transparent, that making comparisons between assets with valid HI and those without valid HI are done with full understanding of the variation in accuracy. This ensures that assessments based on incomplete, not valid, HI are not tilting the investment decisions in an inappropriate direction either towards or away from the true need.

**CAPITAL INVESTMENT PLANS**

1. **Assumptions and Approach**

ACA is the primary driver for renewal investments, which Enersource bases on the “flagged for action” plan within the ACA. Assets not evaluated in the ACA are replaced based on inspection criteria. Enersource had begun the process of moving towards an updated value model but deferred that due to the announcement of the merger.

While Enersource does not yet apply a quantitative method, we did review with Enersource the tools they are leveraging to move towards a quantitative method. The capabilities that they have assembled are very strong and it is clear that Enersource is close to moving toward a best practice capability in assessing the impact on reliability of the ACA results. Enersource currently uses those tools outside of the ACA process as part of the smoothing or identification of how best to optimize the replacement levels identified by the ACA.

This method is not applied comprehensively as yet, presumably only in cases where the ACA model can provide risk values and the asset types lend themselves to assessments of reliability impact.
Planning and AM work closely together to coordinate projects so that system expansion and investments generated by other drivers (road widening, etc.) are leveraged to incorporate or optimize assets identified in the ACA as in need of replacement.

2. ACA Translation

In the development of the capital investment plans, it appears that “Flagged for action” assets are a significant driver of the renewal plans as well as the overall spending levels. We believe that Enersource is making renewal investment decisions based on both proactive and reactive spending expectations.

For those assets where the spending is proactive, the cumulative probability of failure (based on Health Index) times criticality index is the basis for identifying assets in need of replacement. For some proactive assets, the criticality is assumed to be the same for each asset, which is effectively a spending program based on health only.

For those assets where the spending is reactive, replacement rates are based on estimated probability of failure per ACA, we note that the failure rates are not calibrated to recent experience and thus may not be as accurate a predictor of spending needs as possible. However Enersource is aware of this gap and is working to address it by comparing industry data with its own history, perhaps through CEATI.

ACA recommendations are an input, supplemented with review based on condition, remaining value of the asset, customer effect, reliability, etc. At present this is mainly a subjective task, creating programs out of the overall recommendations. As an example the Enersource ACA identifies the need to replace 100 pad mount switchgear, but Enersource will undertake a greater number of replacements because of PCB concerns. Another example that highlights the efforts that Enersource has taken to bring greater insight into the process is the use of GIS tools to map risk factors attributed to transformers (reliability, PCB, condition, etc.) to support the planning of the cable replacement program which includes other UG assets and the transformers. This results in Enersource getting scale economies while addressing the aggregate highest priorities.

3. Constraint Analysis

Proactive replacement budgets that are driven from the ACA are converted to accepted budgets and are then smoothed and compared with system plans to seek out economies of scale and resource.

Investments and investment programs are prioritized based on effect of delay using prioritization tools. The results are then vetted by SMEs and adjustments made based on that input.

Enersource has recognized that there are both capital constraints and resource constraints. The capital constraints are the result of the need to moderate the impact on rates. The resource constraints are driven largely by the availability of contractors to undertake the field work. There is a finite level of resource in the province. Going outside of the province changes the cost of the work. Enersource appears to do a good job in working with the contracting partners to understand the availability of construction resources based on the province wide workloads.

It does not appear that constraints in either capital or workload are causing Enersource to defer work that it believes must be done immediately.

Enersource has well defined standards for mandatory work. It appears that these standards and definitions eliminate the potential for non-mandatory work to masquerade as mandatory work thereby bypassing the prioritization and screening processes.

Enersource has not yet tested its improved methodologies and their recent improvements in Asset Management processes for capital in front of OEB. Its most recent rate case was before the current AM team was formed.
4. **Reasonability Testing**

During the course of the development of the ACA and capital investment profile, Enersource takes several steps that provide sensible reasonability tests. The first that Enersource leverages multiple times throughout the process is a subjective review by AM team and senior SMEs in the organization. This ensures that the results of the tools are matched with the knowledge and experience of the people that understand the system the best.

Enersource is also very active in seeking informal discussions with peer utilities to gain insights as well as test their findings against those of other utilities in similar circumstances.

Enersource does extensive work to understand the resource requirements as well as the resource availability and ramp up times to ensure that the work that it proposes is actually achievable within the projected time frames. This ensures not only that the schedule is achieved, but also that the cost rates for the workforce are consistent with the projections.

Enersource has not been in the practice of conducting sensitivity analysis around changed assumptions in ACA, especially failure probability and criticality. We believe that adding this capability, which may require bringing the ACA work in-house, would enable Enersource to better stress test its assumptions and its plans.

Likewise, Enersource has not yet attempted to quantify cost/benefit from the customers’ perspective, which could enable Enersource to adjust its spending plans to better address the areas of customer concern.

5. **Optimal Investment Profile**

Specific projects are identified by taking ACA results and incorporating as much of the replacement work as possible into overall system plans. Projects are identified and scored for prioritization and risk according to corporate drivers. Enersource acknowledges that its prioritization process is limited and does not lend itself to the level of optimization that it has targeted. Enersource appears to be working to improve its understanding of the gaps between its current approach and where it believes it needs to be with respect to best practice optimization. Enersource is working to incorporate an updated value and risk model, and has begun investigating decision support tools such as Copperleaf, that it believes would enable it to improve the ability to test its inputs and assumptions. Enersource does not currently undertake routine scenario analysis or stress testing on its drivers.

The process that it uses for ranking and prioritizing investments is common in the industry and is a natural step in the evolution towards true optimization based on value and risk.

**RESULTING EXPENDITURE LEVELS**

The resulting expenditures appear to track well against areas of risk and system performance need. As mentioned above, Enersource does high caliber work leveraging its tools and data to maximize the amount of value and risk that can be addressed in its expenditures.

Enersource’s ACA indicates plans for large expenditures on line transformers and wood poles. These assets are largely run-to-failure (even if failure means identified as “failed” in an inspection). These programs should be calibrated to recent experience, a process we understand is underway internally.

**BEST PRACTICE ASSESSMENT**

One of the requests made of VAI was to undertake an assessment of each of the LDCs against best practices in the areas of ACA (HI) and capital investment planning. The following table provides a summary of the assessments that we have made for Enersource. In undertaking the assessment we have used a set of criteria that we believe represent best practice performance in the areas of ACA and investment optimization. The criterion and their definitions as well as our observations of Enersource against each is included in the table below.
<table>
<thead>
<tr>
<th>CRITERION DEFINITION</th>
<th>VAI ASSESSMENT: ENERSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Determining End of Life</strong>&lt;br&gt;Assets at end of life are identified according to a systematic approach, balancing the cost of continued operation against the cost of replacement to minimize life-cycle cost of ownership. Other interventions, e.g. refurbishment, are considered.</td>
<td>Proactive assets (stations): end of life is determined based on estimated failure probability and subjective (though consistent) measures of consequence. Cost of intervention is not considered.&lt;br&gt;Proactive assets (lines): end of life is determined based on estimated failure probability and a single assumed criticality applied to each asset. Cost of intervention is not considered.&lt;br&gt;Reactive assets: assumed run-to-failure due to perceived low criticality.&lt;br&gt;No business case back-up for these strategies.</td>
</tr>
<tr>
<td><strong>Business Case</strong>&lt;br&gt;Spending recommendations have an accompanying business case that summarizes the problem statement, compares alternatives, and makes a recommendation. All costs and benefits are also quantified from the customers’ perspective; alternatives including the do-nothing alternative are considered; assumptions are stated explicitly and quantitatively.</td>
<td>Prioritization scoring method used to compare projects. Benefits of project are scored in this way, but are not explicitly compared with costs. Overall, a narrative-based business case.&lt;br&gt;Do-nothing is the unstated alternative. Other alternatives may be described but not evaluated for comparison.&lt;br&gt;Alternatives to replacement are considered by the SMEs on an asset-by-asset basis for large assets (station transformers, breakers) and programmatically for dispersed assets (cable, poles).&lt;br&gt;Benefits and risks are based on customer values (e.g. safety, reliability, environmental).</td>
</tr>
<tr>
<td><strong>Long-Range Projections</strong>&lt;br&gt;Aging asset populations include a projection of future spending needs based on expected future degradation and risk.</td>
<td>Long-range projections are provided in the ACA, based on the assumed replacement strategies for each asset class. These are incorporated into the long-range spending plan.</td>
</tr>
<tr>
<td><strong>Prioritization Across Programs</strong>&lt;br&gt;Spending on replacement, refurbishment, maintenance, and other options are directly compared in equal terms to optimize spending plans and to prioritize across programs.</td>
<td>Prioritization process compares spending across assets in equal terms based on the standard scoring scale.&lt;br&gt;The ACA includes an estimate of risk for some “proactive” asset classes, where risk is probability of failure times expected consequence of failure. The prioritization model also includes an assessment of risk, but the assumptions do not appear to be consistent. Ideally, the way a spending option is scored in ACA should translate directly into the business case and the prioritization model. This will simplify scoring and help ensure “apples-to-apples” comparisons.</td>
</tr>
<tr>
<td>CRITERION DEFINITION (CONT’D)</td>
<td>VAI ASSESSMENT: ENERSOURCE (CONT’D)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>Use of Subject Matter Experts (SME)</strong> Tacit knowledge of subject-matter experts is incorporated into the assessment process. Attention is focused on their areas of expertise (e.g. how best to assess condition) as opposed to complex questions outside it (e.g. how many transformers should we replace each year). SME input is documented explicitly for review and improvement over time.</td>
<td>Internal SMEs review, modify, and approve the Health Index formulations. Their expertise is the basis for evaluating alternative interventions. Subject-matter expertise should be applied to failure probability estimates, consequence costs, and other technical input assumptions in the ACA.</td>
</tr>
<tr>
<td><strong>Risk Assessment</strong> Asset risk is quantified in terms of actual failure probability and expected consequence cost of failure in terms that can be used in business cases and the budgeting process. Risk is included in business cases both as a benefit of spending (e.g. avoided risk) and as part of the cost of the work (e.g. risk of cost overrun).</td>
<td>Failure probability is an estimate of actual failure, but has not been calibrated to even recent failure history for every asset class. Consequences of failure are quantified for a few asset classes. They are not based on actual customer costs or calibrated with the prioritization model. Avoided risk is implicitly included in the business case.</td>
</tr>
<tr>
<td><strong>Condition Assessment</strong> Asset conditions are assessed relative to end-of-life failure criteria (i.e. Health Index). Health Index includes relevant parameters for predicting failure based on known degradation processes, and excludes other factors such as those related to criticality or obsolescence. Age is not included as a condition criterion.</td>
<td>Health Indices are based on major degradation processes and end of life criteria. The formulations are generally within the range of best practice, although recent improvements in the industry (e.g. multiplicative formulation) have not been applied. Ongoing improvement in data collected. The multiplicative approach to health indexing is in contrast to the additive approach used by all four utilities in this review. It is a recent industry innovation wherein condition parameters are multiplied together rather than added. It avoids some of the common problems: “masking,” where a bad test result is hidden amid several good ones, and validity, where there are not enough data available to calculate a valid health index. Relevant parameters are included except where data are known not to be available. Age is included in all formulations. This is mitigated by the focus on effective age rather than Health Index itself as the end output. Factors related to obsolescence or consequence (e.g. oil circuit breakers, PCB transformers) are included in some formulations.</td>
</tr>
</tbody>
</table>
### Failure Probability
The meaning of failure is clearly defined and consistently applied (e.g. end of life failure events that require replacement). The likelihood of failure is determined based on condition, age, and historical data.

Definition of “failure” is not clearly stated, however the AM team takes it to mean any failure to perform. In the ACA, it appears to relate to end of life, since it is driving reactive replacement programs. However, assets such as breakers and direct-bury cable can fail multiple times without being replaced. It is not clear whether this has been considered.

Failure probability is estimated based on effective age, which incorporates calendar age and condition parameters.

### Consequences of Failure (Asset Criticality)
Failure consequences are monetized and related directly back to the customer as an outage cost or willingness-to-pay social cost. Consequence costs are intended to reflect the perceived cost to the customer. For example, how much would a ratepayer be willing to pay on a monthly basis to reduce or avoid power outage events?

Where appropriate, multiple failure scenarios are considered and weighted according to their relative likelihoods.

Consequences of failure are not monetized or expressed in terms that can be used in decision-making outside the ACA, e.g., prioritization or business cases.

Costs are customer focused, though implicitly.

Multiple failure scenarios are not considered.

### Processes Documentation
Work flow processes are documented for significant tasks within the organization. The roles and responsibilities of each individual are documented and reviewed on a regular basis.

The required flow of data to support asset management is documented. This includes data collection and storage, data requirements for program development, and data requirements for project justification and prioritization in the budgeting process.

Since the ACA is largely outsourced to a consultant, there is less need for detailed documentation of workflow. Enersource provides review of assumptions and data needed to support the analysis. The plan is to bring the ACA (or other methodology) in-house eventually.

Data requirements are documented in the ACA, e.g. test and inspection results for calculating health.

Matching of projects to the recommended/projected spending levels appears to require significant judgment, difficult to systematize.

### OTHER OBSERVATIONS RELATIVE TO ASSET MANAGEMENT
In our review of the Enersource materials and through our discussions with Enersource personnel we were able to make additional observations relative to the Asset Management organization performance. While we would suggest that Enersource is not yet at best practice level it is well ahead of a large number of the utilities in the industry and above average in terms of its work in ACA results with system performance for maximizing portfolio value. We note that there are numerous clear indicators that continual improvement is underway and well entrenched in the organization, another leading characteristic.

Enersource exhibits several practices that are within range of best practice and others that are already at best practice. Chief among these is the integration of their GIS tools and asset performance data with their investment planning. The work done to migrate data collection to tablets and simplify the process is a leading practice.
Enersource has placed significant emphasis on improvement: expanding HI, and reviewing and improving data collection processes to update GIS data. Enersource is sophisticated in its targeting of asset and component failures and the potential for impact on the ACA. As an example there was significant discussion of porcelain insulators in the context of pole inspection and replacement planning. The AM group is approaching this issue in a manner consistent with best practice: define problem first, decision-making strategy next, then think about solutions.

The areas that we observe would be of greatest value in supporting Enersource’s move toward true best practice include:

- Improving the content and rigour of the business cases;
- Instituting a process for calibration and sensitivity analysis in ACA;
- Developing a rigorous process for computing asset criticality,
  - We note that Enersource’s current methods for integrating the ACA results into the overall system plan, in effect delivers an assessment of criticality, it is just not used in the ACA; and
- Conforming the value and risk criteria used in the ACA to those used in the business cases and prioritization.

These have already been identified by the AM team and appear to be tasks that the AM team is planning to undertake.
**CONCLUSIONS**

Based upon the review of the materials provided by each of the LDCs, the interviews conducted with the LDC personnel and our analysis of the findings, we have identified a number of conclusions that we believe are germane to the potential merger of the four LDCs. In our conclusions we have focused on the potential impacts of the merging of processes, practices and methodologies on the merged entity and resulting capital investment programs.

We have also provided a summary of our assessments of each of the LDCs relative to best practice for the areas related to ACA and capital investment planning.

**Alignment of Methodologies**

**GENERAL**

The ACA practices at Horizon, HOBNI, and Enersource are generally aligned. The approach at PowerStream is somewhat different, but consistent in the sense that it is a more advanced version of the same concept in use at the other three. There is no reason to believe that a merger would result in any major philosophical change of any of the ongoing renewal approaches. It is possible that applying the economic life methodology used at PowerStream to the assets at the other three utilities (and to PowerStream’s cable program) would result in somewhat lower renewal spending, although this is hard to predict with certainty.

All four utilities are aligned in terms of pursuing minimum life-cycle cost as the basis for renewal spending. All are committed to a customer-focused business case approach to making spending decisions. This is important because it means that changes that come about from a possible merger of the asset management practices will tend to be improvement opportunities at the margin due to minor variations in expertise.

**DETERMINING END OF LIFE**

All four utilities use a risk-based approach to determine end of life. Horizon, HOBNI, and Enersource do so only for their proactive programs, and even then they are not as sophisticated as PowerStream, who make explicit estimates of the cost/benefit trade-off between replacement and continued operation.

**BUSINESS CASE**

All four utilities produce business cases to justify projects, per OEB requirements. The link between ACA, the business case, and the prioritization methods is not as strong for any of the four as it might be. None of the utilities is yet able to make an estimate of reliability improvements (i.e., SAIDI, SAIFI) for a given renewal project, as an example. Best practice utilities are able to predict changes in performance across the corporate objectives with a moderate to high degree of accuracy and consistency.

**LONG RANGE PROJECTIONS**

All four produce long-range spending projections for capital renewal. None yet evaluate maintenance programs on the same terms.

**PRIORITIZATION ACROSS PROGRAMS**

All the utilities score projects in terms of risk and value for prioritization. PowerStream is already moving towards adopting the Copperleaf value model to support this; Horizon and EnerSource are considering it and HOBNI has a similar approach already in place. HOBNI and Enersource apply prioritization/optimization to all capital spend, including non-asset spending.

A single model for all four, with consistent drivers and scoring assumptions that are filtered down to the ACA process will be an important step in normalizing renewal spending across the utilities.
USE OF SUBJECT MATTER EXPERTS (SMEs)

Subject-matter experts have been involved in Health Index formulations at all four utilities. For all of them, expanding this role to include field personnel would improve the formulations and failure scenarios, and would help create buy-in for data collection as well as renewal and maintenance strategies.

CONDITION ASSESSMENT

The approach to condition assessment is the same at all four utilities, although the specifics of what tests and inspections are used and how they are weighted varies. It will be important to standardize this to ensure comparability of equipment health. This could be a challenge in cases where one utility collects some data that another does not. Use of multiplicative Health Indices would help ensure that Health Indices are still valid during the transition period. They are also useful in ensuring that an important bad test is not masked by several good ones, which is sometimes a problem in utilities with lots of test and inspection data available.

All four utilities use health to modify effective age, which is appropriate. The specific conversions vary, but there is not much industry data to support this correlation, so settling on a standard will be a matter of judgment.

FAILURE PROBABILITY

Only PowerStream has calibrated its failure probability estimates to actual failure rates, although the other three LDCs are aware of the need for this and have begun the process. We would expect failure rates versus effective age for a given asset type to be the same at every utility, unless there is some reason to believe otherwise (e.g. different specification, loading policy, etc.). Table 3 below compares the failure probability estimates for select asset classes.

<table>
<thead>
<tr>
<th>ASSET</th>
<th>ENER SOURCE</th>
<th>HOBNI</th>
<th>HORIZON</th>
<th>POWER STREAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substation</td>
<td>54</td>
<td>56</td>
<td>60</td>
<td>96</td>
</tr>
<tr>
<td>Pad Mounted</td>
<td>42</td>
<td>42</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Breakers</td>
<td>56</td>
<td>60</td>
<td>68</td>
<td>66</td>
</tr>
<tr>
<td>OCB</td>
<td>53</td>
<td>51</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>Poles</td>
<td>59</td>
<td>53</td>
<td>59</td>
<td>54</td>
</tr>
<tr>
<td>Wood</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>Underground Cables</td>
<td>30</td>
<td>34</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

This is a significant issue for comparing spending programs, especially for reactive programs or proactive programs where criticality is assumed to be the same for every asset (e.g. breakers at Horizon, HOBNI, and Enersource), because the failure probability curve defines the spending projection. To see this effect, let's compare the failure curve for XLPE cable used by Enersource to that used by PowerStream. Both of these relate to pre-1990s, direct-buried, non-tree-retardant cable. Although there may be different assumptions about the exact range of years for this cable population, we would expect the curves and failure projections to be similar. The figure below shows the survivor curves. You can see that the PowerStream curve projects a substantially lower failure rate as cables age.
What are the implications of this difference in estimated failure probability? If we apply these failure rates to a hypothetical population of cables, we can see the dramatic difference in number of failures projected. The figure to the right shows a fictional population of cables by installation date along with the total number of failures projected.

![Comparison of survival curves for non-tree-retardant, direct buried XLPE cable used by PowerStream and Enersource.](image)

Even though the differences in the parameters may seem small, the projected failure rates differ by a factor of nearly 4:1 by age 35.

<table>
<thead>
<tr>
<th>FAILURE PROBABILITY CURVE</th>
<th>ANNUAL PROJECTED FAILURES (fictional population above)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enersource</td>
<td>35</td>
</tr>
<tr>
<td>PowerStream</td>
<td>9</td>
</tr>
</tbody>
</table>

The projected failures from the fictional sample population from the Enersource curve are nearly four times higher. Since projected failure rate is the basis for the replacement or injection program at all four utilities, these differences in failure assumptions could create significant differences in the projected long-range spending need for renewal. Similar outcomes can be shown for other asset classes, but this example is enough to highlight the point. The point is not that one of these curves is wrong and the other right, but rather that there may be substantial differences in planned replacement spending among the utilities, which we expect would begin to converge as they acquire more data and analytical capability.

The solution, which is already underway at both Enersource and PowerStream, is to calibrate the failure probability curves to match actual failure rates. This can be done fairly easily using each utility’s own data, but sharing data or working through a group such as CEATI to have larger amounts of data to work with is recommended where possible.

**CONSEQUENCES OF FAILURE (ASSET CRITICALITY)**

PowerStream takes the most rigorous view of consequence cost of failure, actually counting customers by type and evaluating both major and minor scenarios. However the other utilities are aware of the need for criticality assessment and plan to move in that direction. All of them have the ability to count customers affected by failure of an asset (including cable) through connectivity models.
Best Practice Assessment

The table below summarizes the overall performance of the asset management functions at the four utilities relative to industry best practice (legend to the right). It should be noted that many, perhaps most, electric utilities are not practicing asset management in any meaningful sense. Our assessments and comparisons to Best Practice includes only those utilities that have made a significant effort to implement a program and apply it. If we were to apply these assessments and compare across the industry as a whole, each of the utilities would move to the right on these charts.

The bell curves below are intended to show where each utility stands relative to the population of utilities actually practicing asset management. Bell-shaped curves are used to reflect the fact that the large majority of utilities lie somewhere in the middle relative to best practice. These rankings represent our overall assessment; for more detail refer to the sections of this report specific to each utility.

We recognize that not all four asset management groups have been in place for very long. We have tried to make allowance in our ratings for plans for future improvements that appear to be already underway.
### Prioritization Across Programs

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>High end of normal</td>
<td>About normal</td>
<td>High end of normal</td>
<td>About normal</td>
</tr>
</tbody>
</table>

### Use of Subject Matter Experts (SMEs)

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>About normal</td>
<td>About normal</td>
<td>About normal</td>
<td>About normal</td>
</tr>
</tbody>
</table>

### Risk Assessment

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>High end of normal</td>
<td>Low end of normal</td>
<td>Low end of normal</td>
<td>Low end of normal</td>
</tr>
</tbody>
</table>

### Condition Assessment

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>High end of normal</td>
<td>About normal</td>
<td>About normal</td>
<td>About normal</td>
</tr>
</tbody>
</table>

### Failure Probability

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>High end of normal</td>
<td>About normal</td>
<td>About normal</td>
<td>About normal</td>
</tr>
</tbody>
</table>

### Consequences of Failure (Asset Criticality)

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best practice</td>
<td>Low end of normal</td>
<td>Low end of normal</td>
<td>Low end of normal</td>
</tr>
</tbody>
</table>

### Processes Documentation

<table>
<thead>
<tr>
<th>PowerStream</th>
<th>Horizon</th>
<th>HOBNI</th>
<th>Enersource</th>
</tr>
</thead>
<tbody>
<tr>
<td>About normal</td>
<td>About normal</td>
<td>High end of normal</td>
<td>About normal</td>
</tr>
</tbody>
</table>
CREDITS

Interviews conducted by Stewart Ramsay and Darin Johnson
Observations and Assessments prepared by
Neil Reid, Darin Johnson and Stewart Ramsay
Report written by Darin Johnson and Stewart Ramsay
Edited by Darin Johnson, Tracey Lawrence and Yvette Smith
Thank You.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 41:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 2
Exhibit 2B, Section D, Appendix C, p. 4

At Reference #1, THESL indicates with the CNAIM it uses inspection data and individual HI scores, in combination with other information and professional judgement to prioritize assets for tactical intervention in the short to medium term.

At Reference #2, THESL indicates that using its previous ACA methodology, assets were placed into five condition categories based on the HI, from best condition to worst condition, and while these different asset categories could be assigned a suggested range in time to replacement (e.g. an asset in very poor condition may generally need to be addressed in one to two years), these ranges were based primarily on engineering judgment and did not provide a precise analytical basis for assessing asset risk and more precise replacement needs based on condition.

a) Please explain the similarities and differences in the level of use of professional and engineering judgment between the two ACA methodologies to prioritize assets for intervention.

b) Please discuss if the current matching of projects to the recommended/projected spending levels requires significant judgment or is it systematic.
c) Please summarize the other information used in the CNAIM to prioritize assets for tactical intervention in the short to medium term.

d) With respect to Ref #2, please explain why the previous ACA methodology did not provide a precise analytical basis for assessing asset risk and more precise replacement needs based on condition.

e) Please explain further how the CNAIM methodology provides a more precise analytical basis for assessing asset risk and more precise replacement needs based on condition.

RESPONSE:

a) The new ACA methodology based on the CNAIM Algorithm is a more mature and advanced methodology which emphasizes deficiencies that directly impact equipment failure. Therefore, Toronto Hydro can place more confidence in the analytical results it provides when compared to the previous ACA methodology (weighted arithmetic mean algorithm). As with any analytical tool or process, engineering judgement plays a role, to ensure that decisions being recommended by these tools are efficient and effective at the time of execution.

b) Toronto Hydro uses a systematic approach which includes various tools and processes to identify and develop investment programs and projects. For an explanation of Toronto Hydro’s Asset Management Process, please refer to Exhibit 2B, Section D1. As stated in part a), engineering judgement will play a role throughout the process, in order to ensure that the decisions being made are efficient and effective. For more details on the systematic process of identifying investment opportunities within the
distribution system, please refer to Toronto Hydro’s response to interrogatory 2B-
Staff-67 (e).

c) To clarify, “other information” mentioned in Exhibit 2B, Section D, Appendix C, Page 2, Line 23 is meant to refer to information that is outside of the CNAIM methodology. This information includes the various tools mentioned in Exhibit 2B, Section D3 to prioritise assets for tactical intervention in the short to medium term.

d) The old ACA algorithm had a number of limitations which are mentioned in Exhibit 2B, Section D, Appendix C, pages 3-5. The most important issue was masking of critical conditions that lead to total asset failure by all other benign condition attributes.

e) Please refer to Exhibit 2B, section D, Appendix C, pages 6-7 for how the CNAIM methodology provides a more precise analytical basis for assessing asset risk and more precise replacement needs based on condition.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 42:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 4

a) Please provide a copy of the ACA THESL used to underpin the capital plan in EB-2014-0116 application.

b) Please provide a copy of THESL’s most recent ACA prior to the change in methodology in 2016 to CNAIM.

RESPONSE:

a) Please refer to Appendix A of this response.

b) Table 1: 2016 ACA Results Prior To Changing The ACA Algorithm

<table>
<thead>
<tr>
<th>No.</th>
<th>Asset Type</th>
<th>Total Population</th>
<th>% Sample Size</th>
<th>Very Poor (HI &lt; 30)</th>
<th>Poor (30 ≤ HI &lt; 50)</th>
<th>Fair (50 ≤ HI &lt; 70)</th>
<th>Good (70 ≤ HI &lt; 85)</th>
<th>Very Good (HI ≥ 85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AIRBLAST CIRCUIT BREAKER</td>
<td>241</td>
<td>75.9%</td>
<td>0.0%</td>
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Toronto Hydro-Electric System Limited
2014 Asset Condition Assessment Audit

Kinectrics Inc. Report No: K-418649-RA-R00

June 20, 2014
DISCLAIMER

Kinectrics Inc. has prepared this report in accordance with, and subject to, the terms and conditions of the agreement between Kinectrics Inc. and Toronto Hydro-Electric System Limited

@Kinectrics Inc., 2014
June 20, 2014

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Dated: June 20, 2014
To: Charles Keizer
Torys LLP
79 Wellington St. W., 30th Floor
Box 270, TD South Tower
Toronto, Ontario M5K 1N2 Canada

Revision History

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# Table of Contents

1 Introduction ........................................................................................................................................ 1
2 Comparison of 2012 and 2014 ACA Methodology ....................................................................... 2
3 Key Achievements Between 2012 and 2014 .................................................................................. 3
4 Audit Results ...................................................................................................................................... 7
   4.1 Changes in Health Index Formulation ....................................................................................... 7
   4.2 Changes in Asset Category or Granularity ............................................................................... 7
   4.3 Changes in Population and Sample Size .................................................................................. 8
   4.4 Changes in Health Index Distribution ..................................................................................... 13
5 Conclusions ....................................................................................................................................... 19
6 Recommendations ............................................................................................................................ 22
Appendix A: Audit Results by Asset Class ......................................................................................... 25

1 Station Power Transformers ............................................................................................................. 27
   1.1 Changes in Health Index Formulation ...................................................................................... 27
   1.2 Changes in Granularity ............................................................................................................. 27
   1.3 Changes in Sample Size ........................................................................................................... 27
   1.4 Changes in Health Index Classification .................................................................................. 28
2 Station Switchgear ............................................................................................................................ 29
   2.1 Changes in Health Index Formulation ...................................................................................... 29
   2.2 Changes in Granularity ............................................................................................................. 29
   2.3 Changes in Sample Size ........................................................................................................... 29
   2.4 Changes in Health Index Classification .................................................................................. 30
3 Air Blast Circuit Breakers .................................................................................................................. 31
   3.1 Changes in Health Index Formulation ...................................................................................... 31
   3.2 Changes in Granularity ............................................................................................................. 31
   3.3 Changes in Sample Size ........................................................................................................... 31
   3.4 Changes in Health Index Classification .................................................................................. 32
4 Air Magnetic Circuit Breakers .......................................................................................................... 33
   4.1 Changes in Health Index Formulation ...................................................................................... 33
   4.2 Changes in Granularity ............................................................................................................. 33
   4.3 Changes in Sample Size ........................................................................................................... 33
   4.4 Changes in Health Index Classification .................................................................................. 34
5 Oil Circuit Breakers .......................................................................................................................... 35
   5.1 Changes in Health Index Formulation ...................................................................................... 35
   5.2 Changes in Granularity ............................................................................................................. 35
   5.3 Changes in Sample Size ........................................................................................................... 35
   5.4 Changes in Health Index Classification .................................................................................. 36
6 Oil KSO Circuit Breakers ................................................................................................................... 37
   6.1 Changes in Health Index Formulation ...................................................................................... 37
   6.2 Changes in Granularity ............................................................................................................. 37
   6.3 Changes in Sample Size ........................................................................................................... 37
   6.4 Changes in Health Index Classification .................................................................................. 38
7 SF6 Circuit Breaker ............................................................................................................................. 39
   7.1 Changes in Health Index Formulation ...................................................................................... 39
17 Automatic Transfer Switches

17.1 Changes in Health Index Formulation

17.2 Changes in Granularity

17.3 Changes in Sample Size

17.4 Changes in Health Index Classification

18 Network Transformers

18.1 Changes in Health Index Formulation

18.2 Changes in Granularity

18.3 Changes in Sample Size

18.4 Changes in Health Index Classification

19 Network Protectors

19.1 Changes in Health Index Formulation

19.2 Changes in Granularity

19.3 Changes in Sample Size

19.4 Changes in Health Index Classification

20 Network Vaults

20.1 Changes in Health Index Formulation

20.2 Changes in Granularity

20.3 Changes in Sample Size

20.4 Changes in Health Index Classification

21 Cable Chambers

21.1 Changes in Health Index Formulation

21.2 Changes in Granularity

21.3 Changes in Sample Size

21.4 Changes in Health Index Classification

Appendix B: Glossary of Terms
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1 Introduction

Over the past number of years, Toronto Hydro-Electric System Limited (THESL) has been putting forth considerable efforts to improve its Asset Management (AM) practices.

In 2006, a full Asset Condition Assessment (ACA) for THESL’s key distribution assets was conducted by Kinectrics Inc (Kinectrics). Between 2006 and 2009, THESL developed the Calculator, an application that evaluates asset Health Indices based on available condition data and Kinectrics Health Index formulations. In 2009, following an ACA THESL internally conducted using the Calculator, Kinectrics was engaged to audit THESL’s progress and to compare the results of the 2006 and 2009 ACAs.

Between 2009 and 2010, THESL continued to make improvements to the Calculator and adopt the recommendations from Kinectrics 2009 audit. In 2010 THESL conducted a condition assessment of its key assets. Additionally, Kinectrics performed a standalone ACA of Network Transformers, Network Vaults, and Network Protectors. Kinectrics then conducted a second audit of the progress made between 2009 and 2010. A significant change during this time period was the migration of the Calculator from Microsoft Excel to a web-based, Business Intelligence (BI) platform. The intent of this change was to improve accessibility and visibility of the condition assessment process across the organization, create greater data management and integration capabilities, and to enhance THESL’s analytics and reporting tools.

Following the 2010 audit, THESL continued with annual ACAs and systematic reviews of the Calculator. Efforts to improve data quality and availability continued. In both 2011 and 2012, condition assessments were conducted internally by THESL. In 2012, Kinectrics performed a third audit for the time period between 2011 and 2012.

Since the 2012 audit, there have been continued efforts to improve the Asset Management process. THESL maintains its focus on improving the availability of asset condition data and the means by which it internally evaluates asset Health Indices. Additionally, THESL’s practice of annual condition assessments and ongoing review of the condition assessment process demonstrates a commitment to continuous improvement. Utilities across North America are recognizing the value of benchmarking asset condition and reassessing at regular intervals to determine not only current state but also to assess the progress made with respect to improving Health Index formulas, data quality and quantity, and collection and integration methods. THESL’s processes and procedures are in keeping with such leading practices.

In March of 2014, a sixth ACA was completed internally by THESL. This assessment was conducted with the Interim ACA Calculator, a temporary tool used while the BI Calculator undergoes improvements and modifications. Kinectrics has been asked to assess the progress between 2012 and 2014. The data and information were provided by THESL and is reported by THESL to be current up to March 13, 2014. All information supplied by THESL is assumed by Kinectrics to be accurate and complete. This report describes the Kinectrics findings.
2 Comparison of 2012 and 2014 ACA Methodology

Health Index (HI) formulations and results from 2012 and 2014 were compared for the following twenty-one (21) asset classes:

- Stations Power Transformers
- Station Switchgear
- Air Blast CB
- Air Magnetic CB
- Oil CB
- Oil KSO CB
- SF6 CB
- Vacuum CB
- Submersible Transformers
- Vault Transformers
- Padmounted Transformers
- Padmounted Switches
- 3φ OH Gang Manual Switches (Overhead Manual Switches)
- 3φ OH Gang Remote Switches (Overhead Remote Switches)
- SCADAMATE Switches
- Wood Poles
- ATS
- Network Transformers
- Network Protectors
- Network Vaults
- Cable Chambers

Note that for the Network Protectors category the 2014 results were compared to those from 2010. This is because no other assessments were performed for this category since the 2010 network assessment by Kinectrics, as detailed in the “Toronto Hydro-Electric System Limited Networks Asset Condition Assessment” report issued on July 16, 2010.

These 21 asset classes generally belong to one of four categories:

1. Station Assets: Station Power Transformers, Station Switchgear, Circuit Breakers
2. Underground Assets: Vault, Padmounted, and Submersible Transformers, Padmounted Switchgear
3. Overhead Assets: Overhead Switches, Wood Poles
4. Network Assets: ATSS, Network Transformers, Network Protectors, Network Vaults, Cable Chambers

In 2012 all asset categories, with the exception of Station Power Transformers and Network Vaults, were assessed by THESL using the BI Calculator. For Station Power Transformers, it was found that the BI business rule for capturing data from the last inspection date did not adequately capture data from multiple inspection periods. As such, this asset class was assessed manually in 2012. Network Vaults were assessed manually in 2012 because the new Health Index formulations developed in the Kinectrics 2010 network assessment had not yet been incorporated into the BI Calculator.
For the 2014 ACA, THESL made the decision to use a temporary Microsoft Excel based tool, the Interim ACA Calculator. Like the BI Calculator, the Interim ACA Calculator extracts asset information from THESL’s Ellipse database and calculates Health Indices using formulas consistent with those in the BI Calculator.

The decision was made to use the Interim ACA Calculator because the BI Calculator is currently being validated and modified. There are elements of the BI Calculator (e.g. data sources, queries of inspection data, classification of units to the correct asset class) that require updates that would not have been completed in time for the 2014 ACA. The Interim ACA Calculator already incorporates these required changes and improvements. As such, THESL has greater confidence in the credibility of the results generated by the Interim ACA Calculator. Unlike the BI Calculator which is visible across the organization, use of the Interim ACA Calculator reduces visibility of the assessment results for THESL organizations outside of the Asset Management group. The Asset Management group has ensured, however, that such organizations are supplied with any information they may require.

THESL reports that once the improvements BI Calculator are completed, the BI Calculator will again be used for future ACAs.

3 Key Achievements Between 2012 and 2014

The key achievements with respect to THESL’s Asset Management practices between 2012 and 2014 are highlighted below:

1. **Improved Maintenance Practices:** Several changes, listed as follows, have been made to maintenance practices to improve inspection data quality and consistency.
   - THESL has expanded the scope of transformer oil testing (e.g. oil quality tests, furan analyses, dissolved gas analysis (DGA)) to include transformers outside of THESL’s transformer stations. THESL-owned transformers at customer locations are now subject to such oil tests.
   - Use of enhanced inspection forms for all station assets, network vaults, cable chambers, and overhead switches. In the new forms, there is increased use of drop-down comments as opposed to free-form text. These changes will improve data quality and accuracy.
   - Improved record keeping for assets, namely line disconnects, bus disconnects, fuse compartments, and relays. Inspections and maintenance records for these assets are now in the Ellipse database.
   - Improvement of inspection forms for Wood Poles and migration of data into Ellipse. Inspectors will also provide remaining pole strength in PSI.

2. **Maintenance Tools:** Consistent with THESL’s focus to improve inspection data quality and consistency, THESL has purchased maintenance tools to be tested as prototypes. Depending on quality of data produced, these will become part of the mainstream programs. Such tools include:
3. **Training of Inspectors:** Improvements have been made to the training program to improve inspection data quality and consistency:
   
   - Maintenance Manuals were restructured with additional technical information, as well as photos of deficiencies and varying asset conditions.
   
   - A training program is being developed specifically on the subject of inspection criteria. The training documents have been created for each maintenance program.

4. **Comprehensive Reviews of ACA Asset Classes:** THESL has taken the initiative to review all asset classes that are included in the ACA program. The goal for each of the asset classes was to identify data gaps limiting sample size and to validate the Health Index formulas and data currently used in the BI Calculator.

   The analyses identified areas of improvement and necessary corrections related to the BI Calculator. It contributed to THESL’s decision to develop a standalone Interim ACA Calculator for its 2014 Asset Condition Assessment while the BI Calculator undergoes necessary modifications.

5. **Address Recommendations from the 2012 Kinectrics Audit:** Note that since recommendations from past audits had been included and/or incorporated in the 2012 audit, only the 2012 recommendations are shown. THESL continues with efforts to address the recommendations from the 2012 Kinectrics audit. The Kinectrics recommendations and actions taken by THESL are as follows:

   - **2012 Recommendation 1:** Validate the Wood Poles Data that has been migrated into Ellipse; process the data so that they are useable by the BI Calculator.

     Old inspection data has been migrated into Ellipse and all new inspection records are stored in Ellipse.

   - **2012 Recommendation 2:** Make improvements to the BI Calculator, specifically:

     *Revise inspection data queries for Station Power Transformers:* Although Station Power Transformers are included in the BI Calculator, the tool still requires modifications to ensure that all inspection and test data are captured. Note that the Interim ACA Calculator accounts for and includes all available inspection and test data.
Use 2010 Health Index formulations for Network Vaults and Network Transformers: THESL has not yet incorporated the Kinectrics 2010 formulations for Network Vaults and Network Transformers into the BI Calculator, however THESL continues to examine the feasibility of implementing this recommendation.

Add Network Protectors as a new asset category: While Network Protectors have not been added to the BI Calculator, it was included in the standalone Interim ACA Calculator and included in THESL’s 2014 ACA. As well, THESL continues to examine the feasibility of adding this asset category to the BI Calculator.

Add Underground Cables as a new asset category: The Underground Cables asset class has not yet been added to the BI Calculator. THESL feels that it is imperative to first test cables to determine the degree of deterioration, and then afterwards consider how to include such test results the cable Health Index formula. Progress is being made with regards to the preferred type of testing. Underground cable testing has not yet commenced, however it is THESL’s goal to have a pilot project in the near future.

Outside of the above recommendations, THESL has made or is in the process of making additional enhancements to the BI Calculator. Enhancements that have already been completed include:

- Modification of calculation method to ensure that the correct age of an asset is used in the assessment.
- Improved presentation of data and information for better readability.

Enhancements that are currently underway include:

- Addition of “asset owner information” as a selectable filter in the BI Calculator report. This allows for prompt filtering and selection of assets belonging to THESL versus assets belonging to other owners (e.g. Hydro One Networks Inc).
- Improving the identification and classification of overhead switches and padmounted switches. The current version of the BI Calculator incorrectly classifies some remotely operated switches as manually operated switches. As well, the number of air insulated padmounted switch units are not being identified as Padmounted Switches. Note that the Interim ACA Calculator used in the 2014 ACA correctly identifies and classifies overhead and padmounted switches.
- Improving the data source of certain condition parameters. This applies to the parameters “IR Hotspot” and “Dirty” for Station Switchgear, as well as “Phase Barriers” for the ATS asset category. Note that the Interim ACA Calculator uses the correct data sources for the aforementioned parameters.
• **2012 Recommendations 3 and 4:** Increase the sample size of each asset category; Continue with the practices of collecting additional and more complete data for assets (e.g. use of handheld devices during inspections).

THESL has made great strides in and continues with efforts to increase the sample size of its assets. The sample size increased for 20 of the 21 asset groups included in the audit. THESL reports that the use of handheld electronic data collectors (e.g. PDAs, tablets, laptops) by THESL inspectors is a major contributor to increasing sample sizes. Additionally, when inspections are performed by external contractors, THESL requires that the results be submitted electronically so that they may be easily integrated into THESL’s databases.

• **2012 Recommendation 5:** Work on short term plans (manpower and expenditures) for assets that have large quantities in poor and very poor condition, as well as long term plans for assets that have large quantities in fair condition.

THESL continues short and long term planning for its assets using ACA results as one of the drivers. In general, THESL prioritizes replacement of assets in the capital budget using ACA results. Higher priority for replacement is given to those assets with the worst Health Index scores. This is especially applicable for stations assets.

Note that ACA is not the only driver that THESL uses for short and long term planning. Asset classes with functionally obsolete designs may not have the worst ACA scores but are nonetheless targeted for replacements (e.g. lack of spare parts, no manufacturer support, increased maintenance required). Such examples include ATSs and Fibertop network protectors.

Furthermore THESL must also consider operational constraints when replacing assets. For example, in order to replace a switchgear lineup at a station, all load must be transferred to a new lineup, if space exists, or to other switchgear lineups in neighboring stations. In the event where there is no space available for a new lineup and capacity constraints exists, extended timelines can result.

• **2012 Recommendation 6:** Adopt the recommended Health Index formulations presented in the Kinectrics 2010 Audit. If required, refine Health Index formulations and determine what parameters are feasible from an operational perspective.

The Health Index formulas presented in the 2011 audit have not been incorporated into the BI or Interim Calculators, however as THESL reviews asset classes that are included in the ACA program, THESL looks for opportunities to refine current Health Index formulas.

• **2012 Recommendation 7:** Continue with progress made related to risk analysis, refurbishment versus replacement analysis and failure data collection.

ACA results are incorporated into THESL’s "feeder investment model" (FIM). This tool optimizes distribution system asset decisions through:


4 Audit Results

For each Asset Category, the following aspects were compared between 2012 and 2014:

1. Health Index Formulation
2. Granularity within the Asset Category
3. Population and Sample Size
4. Health Index Distribution

The 2014 ACA results, including population, sample size, and Health Index distribution of each relevant asset category, were provided to Kinectrics by THESL.

4.1 Changes in Health Index Formulation

Between 2012 and 2014, THESL reports that there have been no changes with respect to Condition Parameters, Weights, and Condition Criteria.

There were, however, changes in the Interim ACA Calculator with respect to the data sources of the “IR Hotspot” and “Dirty” Condition Parameters for Station Switchgear. These changes were made such that correct or improved data would be used to as input into the Condition Parameters. Similarly, the data for “Phase Barriers” in the ATS asset category was changed.

4.2 Changes in Asset Category or Granularity

The assets within each asset category do not represent a homogeneous set of equipment as there are variations in manufacturers, models, types, ratings, installations, environments, etc. All of these factors have impacts on the condition of individual assets and their corresponding Health Index. At the same time, the Health Index approach is most meaningful when looking at the asset categories with substantial number of assets. It is therefore important to establish a right balance between similarity and number of assets in selecting the appropriate granularity for asset categories.

Network Protectors, which were introduced as a separate category in the Kinectrics 2010 standalone network assessment, were assessed in 2014. Although this asset category has not yet been incorporated into the BI Calculator, it was included in the Interim ACA Calculator developed for the 2014 assessment.

There have been no other changes in asset categories or asset granularity between 2012 and 2014.
4.3 Changes in Population and Sample Size

Table 1 summarizes the Change Population and Sample Size between 2012 and 2014. Graphical representations of the data are given on Figure 1 and Figure 2.

Changes in Population

The populations remained steady, i.e. changed by 1% or less, for 7 of the 21 asset groups. Six (6) asset categories had slight changes, between 2% to 5%, in populations. Two (2) asset groups had population changes within the range of 8% to 9%. The remaining 6 categories had more significant changes, over 15%, in populations.

A slight decrease in the Station Power Transformer and Station Switchgear populations was observed. THESL reports that the difference is a result of a cleanup of Ellipse records, as well as decommissioning (e.g. transformer decommissioning because of decreased load or 4.16 kV station decommissioning).

While the Air Blast and Air Magnetic Breakers populations remained steady, there have been decreases in the Oil, Oil KSO, and SF6 Breaker populations (17%, 8%, and 16%, respectively). Conversely, the Vacuum Beaker population has increased significantly by 24%. The change in SF6 Breaker population results from data cleansing of Ellipse. The trend with the other breaker types is expected because it is THESL’s practice to replace oil breakers with vacuum breakers.

There were no major changes in the population of underground distribution transformers and Padmounted Switchgear. The Padmounted Switchgear population remained steady. The number of Vault Transformers decreased slightly. The populations of Submersible and Padmounted Transformers both slightly increased by only 3%.

While there was only a slight increase of 4% in Overhead Manual switches, significant changes were observed for Overhead Remote and SCADAMATE switches. The population of Overhead Remote switches dropped by 94%, whereas the population of SCADAMATES increased by 21%. THESL reports that improved data classification in the Interim ACA Calculator and Ellipse data validation are the primary reasons for the change in Overhead Remote classification. In 2012 the overwhelming majority of units classified as Remote switches were, in fact, misclassified Manual switches. A correction was made in the 2014 assessment, and misclassified Remote switches are now correctly included in the Manual switch population. THESL’s intent to improve the sectionalizing capabilities of the distribution network has led to a 21% increase in SCADAMATES. As well, some Manual and Remote switches are being replaced by SCADAMATES.

The number of Wood Poles remained fairly steady.

The 17% decrease in the ATS population was expected because this asset group is currently being eliminated from the system. The Cable Chamber, Network Transformer, and Network Vault populations remained steady.

The population of Network Protectors increased by 9%. Note that in the 2010 Network assessment, the reported population was higher than the 1479 shown in this study. Through data validation, THESL found that there were in fact fewer in-service units than what was in the data set provided to Kinectrics in 2010. THESL reports that the increase in population in 2014
can be attributed to data cleansing of Ellipse and replacement of some ATSs and Reverse Power Breakers (RPBs) with Network Protectors.

**Changes in Sample Size**

Sample size refers to percentage of units within an asset group that have sufficient condition parameter data for Health Index calculation. According to THESL’s 60% Data Availability rule, 60% of an asset’s condition data must be available in order to be included into the sample size. Ideally, at least 60% of required condition data should be available for every asset within a population. Failing that, the larger the sample size, the more confidence there is in extrapolating the ACA results over an entire asset population.

THESL has made significant progress with respect to increasing sample sizes. It was found that the sample size increased for 20 out of the 21 asset groups. Only the Network Vault sample size remained unchanged because the sample size for this asset category is already nearly 100%. Further, the average sample size of all 21 asset categories is nearly 73%. This is a 15% improvement since 2012 where the overall average sample size was 58%. THESL reports that this significant improvement is attributed to using handheld electronic data collectors (e.g. PDAs, tablets, laptops). Such devices eliminate the need for paper records and make data collection mandatory, consistent, and complete during inspections. As well, results from inspections conducted by external contractors are required to be submitted to THESL in electronic format, facilitating data integration into THESL databases.

Many asset classes had significant improvements in sample size. Overhead Manual, Overhead Remote, and SCADAMATE switches, had sample size increases of 27%, 35%, and 25% respectively. The sample size for the Padmounted Switches category increased by nearly 47%. The Air Blast and Air Magnetic Breakers sample sizes increased by 18% and 28% respectively. The biggest increase out of all asset groups was the 55% increase for Station Switchgear.

Generally, a minimum sample size of 10% is required to extrapolate ACA results over an entire population. None of the asset categories had sample sizes below 10%. In 2012 Overhead Manual Switches had a sample size of 6%. In 2014, the sample size had increased to nearly 33%, a 27% improvement since 2012. In addition, of the 770 units that had insufficient data, 512 had 58% of the data required for Health Indexing. These units are very close to meeting THESL’s 60% Data Availability Rule.

THESL has also identified asset categories where the sample size is below 40% and has determined actions that should increase the sample sizes:

- **SF6 and OIL KSO Breakers**: Relative to other assets, breakers have fewer inspection data because historically, there were difficulties with isolating circuit breakers for inspection, as taking them out of service puts the system in a contingency situation. Additionally paper records were used in past ACAs. The use of electronic data collectors is expected to improve the sample sizes for breakers.

- **Overhead Manual Switches**: The use of electronic data collectors is expected to improve the sample sizes for this asset class.

- **Wood Poles**: THESL has only recently begun to record the results from Wood Poles inspections. The sample size will increase as more inspection data is stored in Ellipse.
- Cable Chambers: In the past, only small numbers of cable chambers were inspected annually. The number of units inspected per year has been recently increased to meet a 10-year inspection cycle, and as such the sample size is expected to increase in the future.

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* The audit period for this asset category is 2010 - 2014
Figure 1 Change in Population
Figure 2 Change in Sample Size
4.4 **Changes in Health Index Distribution**

The changes in Health Index distribution between 2014 and 2012 are summarized in Table 2 and graphically in Figure 3.

The overall trend with respect to Health Index distribution was assessed. Assets that showed an increasing percentage of “good” and/or “very good” or a decrease of “very poor”, “poor”, and/or “fair” were classified as having overall improved health distributions. Conversely, asset classes with a decreasing percentage of “good” and/or “very good” or an increasing percentage of “very poor”, “poor”, and/or “fair” were classified as having an overall decline in health.

There has been a downward trend in the overall health of a majority of THESL's asset groups. Of the 21 asset groups audited, only 4 groups showed improvements in overall health. These are Vacuum Breakers, Wood Poles, SCADAMATE Switches, and Padmounted Switches. For the remaining 17 asset categories, an overall decline in condition was observed. The degree of decline in health is qualitatively described as small, notable, significant, very significant, or extremely significant.

The change in the Health Index distribution is an indicator of how THESL is responding to overall health of the system; the Health Index distribution itself provides a snapshot of the overall health of the system. As such, in addition to observing the change in Health Index distribution, the actual 2014 Health Index distributions of each asset category was reviewed. Asset classes that showed significant quantities in the “very poor”, “poor”, and “fair” categories were noted.

**Station Assets**

**Station Power Transformers**: The trend shows a very significant decline in the Health of Station Power Transformers. In 2014, only 36% were classified as “good”/“very good”. This is an 18% decrease since 2012, were 54% were found to be “good”/“very good”.

Because Substation Power Transformers are a substantial asset with high consequences of failure, THESL should plan to address this downward trend. Additional replacement or refurbishment may be required to stop and reverse the rapid decline in the overall health of this asset category.

**Station Switchgear**: A very significant decline in overall health was observed for Station Switchgear. In 2012, 28% were classified as “poor”/“very poor”. In 2014, 42% of the samples were deemed as “poor”/“very poor”, an increase of 13%.

Because Station Switchgear is a substantial asset class, the very large percentage in “poor”/“very poor” conditions is a concern and should be addressed in the near future.

**Circuit Breakers**: With the exception of Vacuum breakers which experienced a 3% increase in units classified as “good”/“very good”, circuit breakers have been experiencing a decline in health:

- The decline in Air Blast CB health was notable. In 2012 12% were classified as “good”/“very good”. In 2014 this number dropped by 4%, as only 8% were considered to be “good”/“very good”.
• The change in Air Magnetic CB health was very significant. In 2014 21% were “good”/“very good”. This is 19% less than in 2012 where 40% were considered “good”/“very good”.

• Oil CBs had a small decline in condition. In 2014, the percentage classified as “poor”/“very poor” increased by 2%.

• There was a very significant decline in Oil KSO CB health. In 2012 over 26% of the population was considered to be in “good” condition. This is a 13% change from 2014 where only 13% were “good”.

• A significant decline in health was also seen in SF6 CBs. In 2014 the percentage of the population classified as “very good” dropped by 9%.

It is also important to consider the Health Index distribution of THESL’s circuit breakers. While nearly all Vacuum and SF6 breakers are either in “good”/“very good” condition, a majority of the other types of breakers are in no better than “fair” condition. Approximately 94% of Oil, 92% of Air Blast, 87% of Oil KSO, and 79% of Air Magnetic breakers were classified as “fair” or worse. Furthermore, 11% of Oil breakers were classified as “poor”/“very poor”.

Underground Assets

Distribution Transformers: In general, there is a decline in the overall health of underground distribution transformers:

• A very significant decline in health was seen for Submersible Transformers. In 2014 about 58% of the population was in “very good” condition. This is a 19% drop from 2012 where over 77% were in “very good” condition.

• A very significant decline in health was also seen with Vault Transformers. In 2014 over 36% of the population was classified as “very good”. This is 12% less than in 2012 where over 48% were in “very good” condition.

• The decline in the health of Padmounted Transformers is extremely significant. In 2012 an overwhelming majority of the population, 89%, was considered to be in “very good” condition. This dropped by 43% in 2014, as only 46% were classified as “very good”.

Despite this downward trend, no distribution transformers are classified as “poor”/“very poor”. It should be noted, however, that 24% of Vault Transformers are in “fair” condition. Because replacements of such transformers pose a challenge to THESL, generally because these transformers are typically the only source of power in the buildings where they are located, appropriate planning must be considered as these assets are degrading over time.

Padmounted Switches: The overall Health Index distribution for Padmounted Switches improved; in 2014 the percentage of the population classified as “good”/“very good” increased by 7%.

Overhead Assets

Overhead Switches: With 22% fewer assets in “very good” condition, there is appears to be a very significant decline in the overall health of Overhead Remote Switches. It should be noted, however, that an overwhelming majority of the 263 switches under the Remote switches
category were misclassified in 2012 and are now correctly classified as Manual switches. As such, there are now only 15 units under the Remote category and the change in health may not be truly indicative of the trend in this asset category’s health. No units are in “poor”/“very poor” condition.

There is a notable decline in the health of assets belonging to the Overhead Manual Switch category. Approximately 6% less of such assets were classified as “very good” in 2014. This asset category includes over 200 units that were classified as Remote switches in 2012. None of these assets are in “poor”/“very poor” condition.

With 4% more samples in “very good” condition, there was a slight improvement in SCADAMATE Switches health.

**Wood Poles:** There is an improvement in the overall health of Wood Poles. In 2014 the percentage of poles classified as “very good” increased by 4%. The Health Index distribution of this asset class is, however, a concern. Approximately 11% are “poor” and “very poor”; 43% are “fair”. There is a significant quantity, over 123,000, of Wood Poles. Replacing the “poor” and “very poor” and eventually the units that are “fair” will likely pose challenges to THESL.

**Network Assets**

**ATS:** The ATS category showed a reduction in units classified as “good”/“very good”, but also a reduction in “poor”/“very poor” units. In 2014, the percentage of the population classified as “good”/“very good” dropped by 10%. However, the percentage of the population classified as “poor”/“very poor” also dropped by 10%. It follows that the percentage of samples classified as “fair” increased by 20%.

**Network Transformers:** There is a very significant decline in the overall health of Network Transformers. The percentage of samples classified as “very good” dropped by 15%. However, no units were found to be in “poor”/“very poor” condition.

**Network Protectors:** There is a significant decline in the overall health of Network Protectors. The percentage of samples classified as “very good” dropped by 8%. No units, however, were found to be in “poor”/“very poor” condition.

**Network Vaults:** An extremely significant decline in health was observed for Network Vaults. In 2012 approximately 62% of all samples were classified as “good”/“very good”. In 2014 this percentage dropped by 45%, as only 17% were classified as “good”/“very good”. It should also be noted that 9% of the Network Vaults sample were found to be in “poor”/“very poor” condition, and a significant quantity, 72%, are in “fair” condition.

**Cable Chambers:** There appears to be a significant decline in the health of Cable Chambers. The percentage of samples classified as “very good” dropped by nearly 8%.
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<td></td>
</tr>
<tr>
<td>Padmounted Transformers</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>0.5%</td>
<td>10%</td>
<td>10.5%</td>
<td>33%</td>
<td>89.0%</td>
<td>-43%</td>
<td>89.0%</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>10.1%</td>
<td></td>
<td>43.5%</td>
<td>33%</td>
<td>46.4%</td>
<td></td>
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</tr>
<tr>
<td>Padmounted Switches</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.8%</td>
<td>13.8%</td>
<td>-7%</td>
<td>35.1%</td>
<td>1%</td>
<td>50.4%</td>
<td>6%</td>
<td>50.4%</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>0.0%</td>
<td>0%</td>
<td>0.4%</td>
<td>7.2%</td>
<td></td>
<td>36.1%</td>
<td>1%</td>
<td>56.3%</td>
<td></td>
<td>56.3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3ф ОГ Gang (Man) Switches</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>4.7%</td>
<td>-2%</td>
<td>56.3%</td>
<td>8%</td>
<td>39.1%</td>
<td>-6%</td>
<td>39.1%</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>3.0%</td>
<td></td>
<td>63.8%</td>
<td>8%</td>
<td>33.2%</td>
<td></td>
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<td></td>
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<tr>
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<td>Year</td>
<td>Very Poor</td>
<td></td>
<td></td>
<td>Poor</td>
<td></td>
<td></td>
<td>Fair</td>
<td></td>
<td></td>
<td>Good</td>
<td></td>
<td></td>
<td>Very Good</td>
<td></td>
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<td></td>
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<td>% Samples</td>
<td>Change</td>
<td>% Samples</td>
<td>Change</td>
<td>% Samples</td>
<td>Change</td>
<td>% Samples</td>
<td>Change</td>
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<td>Change</td>
</tr>
<tr>
<td>3φ OH Gang (Rem)</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>0%</td>
<td>6.6%</td>
<td>9%</td>
<td>63.2%</td>
<td>14%</td>
<td>30.1%</td>
<td>-22%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switches</td>
<td>2014</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>0%</td>
<td>15.4%</td>
<td></td>
<td>76.9%</td>
<td>7.7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37.4%</td>
<td></td>
</tr>
<tr>
<td>SCADAMATE Switches</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.0%</td>
<td>0%</td>
<td>1.7%</td>
<td>-1%</td>
<td>60.9%</td>
<td>-4%</td>
<td>37.4%</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0%</td>
<td>1.1%</td>
<td>-1%</td>
<td>57.3%</td>
<td></td>
<td>41.4%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Wood Poles</td>
<td>2012</td>
<td>2.5%</td>
<td>0%</td>
<td>7.7%</td>
<td>0%</td>
<td>46.0%</td>
<td>-2%</td>
<td>9.6%</td>
<td>-2%</td>
<td>34.2%</td>
<td>4%</td>
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<td></td>
</tr>
<tr>
<td>2014</td>
<td>2.3%</td>
<td>7.6%</td>
<td>0%</td>
<td>44.1%</td>
<td></td>
<td>7.3%</td>
<td></td>
<td>38.6%</td>
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<td></td>
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</tr>
<tr>
<td>ATS</td>
<td>2012</td>
<td>3.4%</td>
<td>-3%</td>
<td>23.7%</td>
<td>-7%</td>
<td>11.9%</td>
<td>20%</td>
<td>35.6%</td>
<td>-5%</td>
<td>25.4%</td>
<td>-5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.0%</td>
<td>17.0%</td>
<td></td>
<td>32.1%</td>
<td></td>
<td>30.2%</td>
<td></td>
<td>20.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Network Transformers</td>
<td>2012</td>
<td>0.0%</td>
<td>0%</td>
<td>0.1%</td>
<td>0%</td>
<td>8.0%</td>
<td>8%</td>
<td>34.4%</td>
<td>7%</td>
<td>57.6%</td>
<td>-15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0%</td>
<td>16.4%</td>
<td></td>
<td>41.5%</td>
<td></td>
<td>42.1%</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Network Protectors</td>
<td>2010</td>
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<td>0%</td>
<td>0.0%</td>
<td>0%</td>
<td>0.9%</td>
<td>3%</td>
<td>27.2%</td>
<td>5%</td>
<td>71.9%</td>
<td>-8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0%</td>
<td>3.7%</td>
<td></td>
<td>32.3%</td>
<td></td>
<td>64.0%</td>
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<td></td>
</tr>
<tr>
<td>Network Vaults</td>
<td>2012</td>
<td>1.1%</td>
<td>1%</td>
<td>5.9%</td>
<td>3%</td>
<td>31.2%</td>
<td>41%</td>
<td>60.9%</td>
<td>-45%</td>
<td>0.9%</td>
<td>0%</td>
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<td>2014</td>
<td>1.7%</td>
<td>8.8%</td>
<td></td>
<td>72.4%</td>
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<td>16.1%</td>
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<td></td>
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<tr>
<td>Cable Chambers</td>
<td>2012</td>
<td>0.1%</td>
<td>0%</td>
<td>1.7%</td>
<td>0%</td>
<td>9.4%</td>
<td>1%</td>
<td>43.5%</td>
<td>7%</td>
<td>45.4%</td>
<td>-8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.3%</td>
<td>1.6%</td>
<td>0%</td>
<td>10.8%</td>
<td></td>
<td>50.2%</td>
<td></td>
<td>37.2%</td>
<td></td>
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</tr>
</tbody>
</table>
5 Conclusions

The changes in ACA results between 2012 and 2014 were assessed based on data and information provided by THESL. Following are the observations:

1. There were 21 asset classes included in THESL’s 2014 Asset Condition Assessment. Twenty of these asset classes were assessed in 2012. The remaining category, Network Protectors, was last assessed in 2010.

2. THESL internally performed the ACA for all asset categories using a new Interim ACA Calculator. As THESL is in the process of validating and updating the BI Calculator, THESL made the decision to use the Interim ACA Calculator for the 2014 ACA. Although the Interim ACA Calculator results are not readily visible to organizations outside of the Asset Management group, the Asset Management team has ensured that the data is communicated to those who may require them.

3. There were no changes with respect to asset granularity. Network Protectors, which were introduced as a separate category in the Kinectrics 2010 standalone network assessment, have not yet been incorporated into the BI Calculator. THESL, however, included this category in the 2014 Interim ACA Calculator and was therefore able to generate a Network Protector Health index distribution.

4. The population has remained steady or changed only minimally for 13 of the 21 asset groups audited. Eight of the 21 asset groups had more substantial changes in population. Changes with respect to the 8 asset groups are as follows:
   - The increase in Vacuum and decrease in Oil and Oil KSO breaker population was expected because Vacuum breakers are being used to replace these other types of breakers. The change in SF6 breaker population is a result of Ellipse data validation.
   - THESL’s intent to improve the sectionalizing capabilities of distribution network has led to a 21% increase in SCADAMATEs. The significant decrease (94%) in Three Phase Overhead Remote Switches can be attributed to improved classification of overhead switches. It was found that the overwhelming majority of units classified as Remote switches in 2012 were in fact Manual switches. In the 2014 assessment such units were correctly classified under the Overhead Remote switch category.
   - Elimination of ATSs from the system has led to a decrease in the ATS population.
   - Additional Network Protectors have been installed since 2012. Among these are replacement units for ATSs and RPBs. Validation of Ellipse data is also a contributing factor to the population increase.

5. THESL has made significant progress with respect to increasing sample sizes. The sample size increased for 20 out of the 21 asset groups. The Network Vault population remained unchanged, as the sample size for this asset category is already nearly 100%. THESL reports that this significant improvement is attributed to THESL crew using
handheld electronic data collectors during inspections, as well as requiring external inspectors to submit data to THESL electronically.

6. None of the asset categories had sample sizes below 10%. In 2012 Manual Overhead Switches had a sample size of 6%. In 2014, the sample size has increased to nearly 33%. THESL has also identified asset categories where the sample size is below 40% and has determined actions that should increase the sample sizes.

These sample size increases provide for more credible Health Index distribution across affected asset categories.

7. There has been a downward trend in the overall health of a majority of THESL’s asset groups. Of the 21 asset groups audited, only 4 groups showed improvements in overall health. For the remaining 17 asset categories, an overall decline in condition was observed.

- Station assets: With the exception of Vacuum Breakers, there were generally fewer station assets classified as “good” or “very good” and an increase in assets classified as “poor” or “very poor”. Because station assets are generally substantial and have relatively higher consequences of failure, this trend in declining health is a major cause for concern.
- Underground assets: While Padmounted Switchgear improved with respect to health, fewer Submersible, Vault, and Padmounted Transformers were classified as “very good”.
- Overhead assets: Both the Remote and Manual types of overhead switches saw a decrease in assets classified as “very good”. SCADAMATE switches and Wood Poles showed improved Health Index distributions.
- Network assets: Overall decline in health was observed for all groups considered to be Network assets.

Extremely significant changes were seen for Padmounted Transformers and Network Vaults. In 2014 the percentage of Padmounted Transformer samples classified as “very good” dropped by 43%. Similarly, the percentage of Network Vaults samples classified as “good”/“very good” dropped by 45%.

The downward trend in Health Index distribution could be partially attributed for more credible information since the sample sizes have increased. At the same time, the results are an indication of a need to increase system renewal investments.

8. The Health Index distribution of an asset group provides a snapshot of the overall health of that asset group. Assets with significant quantities in the “very poor”, “poor”, and “fair” categories were flagged for concern and are as follows:

- Station assets: Nearly all station assets, with the exception of SF6 and Vacuum Circuit Breakers, had significant percentages in “fair” or worse categories. Approximately 65% of Station Power Transformers, 75% of Station Switchgear,
92% of Air Blast breakers, 79% of Air Magnetic breakers, 94% of Oil breakers, and 86% of Oil KSO breakers were classified as “fair” or worse.

Of particular concern are Station Switchgear and Station Power Transformers where 42% and 15% of the units respectively were identified as “poor” or “very poor”.

- Underground assets: Almost no underground assets were in “poor” or “very poor” condition. However, 24% of Vault Transformers were classified as “fair”.

- Overhead assets: Approximately 44% of Wood Poles samples were fair; 10% were “poor” or “very poor”. With a sample size of nearly 47,000 poles, this represents a total of over 25,000 poles in “fair” or worse condition. Extrapolated to the total population of 123,000 wood poles, there may be 66,400 poles classified as “fair” or worse.

- Network assets: Regarding, ATSSs, 32% are considered “fair” while 17% are “poor”. While no Network Transformers were found to be “poor” or “very poor”, 16% are in “fair” condition. Approximately 13% of Cable Chambers are “fair” or worse. Of most concern are Network Vaults where 11% were found to be in “poor” or “very poor” condition and 72% in “fair” condition.

9. THESL reports numerous achievements with respect to Asset Management in the past two years. Among these are improved maintenance practices, such as collection of furan and oil data for transformers not in stations, use of enhanced inspection forms, and inspection of additional asset types not currently included in the ACA process.

10. Consistent with THESL’s focus to improve inspection data quality and consistency, THESL has purchased maintenance tools to be tested as prototypes. Depending on quality of data produced, these will become part of the mainstream programs and further result in increasing credibility of ACA process results.

11. THESL has made efforts to enhance training for its staff. THESL reports that maintenance manuals were restructured and additional training specifically on the subject of inspection criteria are being developed.

12. THESL has put in place a comprehensive review process for ACA asset categories. The analyses identified ways to improve sample sizes, validated Health Index formulations, and identified changes required to the BI Calculator. The outcome of the review process also contributed to the decision to employ the Interim ACA Calculator for the 2014 assessment.

13. THESL continues to make improvements to the BI Calculator. Among these include modification of the calculation methods to ensure that correct asset age is used, improvement of the data sources used for certain parameters, and improved presentation and readability of the Calculator output. Changes recommended from past ACA audits are also being implemented or considered.
14. THESL reports continued use, along with other drivers such as functional obsolescence or operational constraints, of the ACA results as input to its short and long term capital planning processes. Generally, assets found to be in the worst condition are further reviewed with respect to timing and pacing of replacements.

15. Although this report focuses on the Asset Condition Assessment portion of the Asset Management process, THESL has also made some progress with respect to risk assessment and replacement versus refurbishment analysis. ACA results are incorporated into THESL’s feeder investment model (FIM). The FIM optimizes distribution system asset decisions by incorporating probability of failure and risks.

6 Recommendations

Recommendations that should facilitate the improvement of THESL’s Asset Management process are listed below.

1. Continue validating and modifying the BI Calculator so that it may be used in subsequent Asset Condition Assessments. Specific changes recommended are as follows:
   - Revise calculation method for Stations Power Transformers. Ensure that the BI Calculator functions in a manner that allows all available test and inspection data to be captured.
   - Include revised Health Index formulations for Network Vaults and Network Transformers (as per the Kinectrics 2010 standalone asset condition assessment of network assets)
   - Include Network Protectors
   - Once a test program has been implemented and test data has been collected, include Underground Cables
   - Complete the BI Calculator enhancements currently underway (e.g. filtering by asset owner, improved overhead switch classification)

2. Continue to improve sample sizes for every asset category. While THESL has already made significant strides with respect to improving asset sample sizes, particular attention should be given to asset categories with sample sizes below 40%.

3. An overall decline in health for 17 asset categories was observed. In addition to the downward trend of asset health, there are numerous categories with large numbers of units in fair or worse condition. The downward trend and large quantities of fair to worse conditions are a cause for concern.

Although it is possible that the decline in health is partially attributable to better asset knowledge due to the increased sample sizes, it is recommended that THESL examine the root cause of decline in asset health. It is further recommended that THESL review
the timing and pacing of system renewal investments based on the trend in asset health.

Short term strategies are particularly important for asset groups that have large quantities in poor and very poor condition. Long term strategies should be put in place for groups that have large quantities in fair condition. This will allow THESL to pace investments and prevent spikes in required replacement costs in the future. Particular attention should be given to:

- Station Assets (Power Transformers, Switchgear, Air Blast CB, Air Magnetic CB, Oil CB, and Oil KSO CB). These assets have significant consequences of failure. A vast majority of station assets are in no better than fair condition.

- Vault Transformers, Network Vaults, and Wood Poles. Replacements may pose challenges because of significant planning required with respect to timing, manpower, and capital.

4. Because ATSs are being decommissioned, it is recommended that this asset category be removed from future assessments and audits.

5. Because of its small population of 15 units, it is recommended Overhead Remote Switches be removed from future assessments and audits.

6. Consider adopting the recommended Health Index formulations presented in the Kinectrics 2010 Audit. If required, continue refining the recommended Health Index formulations and determine what is feasible from an operational perspective.
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Appendix A: Audit Results by Asset Class
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1 Station Power Transformers

The following illustrate the changes found for Station Power Transformers.

1.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

1.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

1.3 Changes in Sample Size
A summary of Population and Sample Size information for Station Power Transformers is shown on Table 1-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 1-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>2012</td>
<td>276</td>
</tr>
<tr>
<td>2014</td>
<td>268</td>
</tr>
<tr>
<td>Change</td>
<td>-2.90%</td>
</tr>
</tbody>
</table>

![Stations Power Transformers Sample Size](image)

**Figure 1-1 Sample Sizes for 2012 and 2014**
1.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Station Power Transformers are shown on Table 1-2 and graphically represented on Figure 1-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>6.53%</td>
<td>39.59%</td>
<td>36.73%</td>
<td>17.14%</td>
</tr>
<tr>
<td>2014</td>
<td>1.24%</td>
<td>13.64%</td>
<td>49.59%</td>
<td>23.14%</td>
<td>12.40%</td>
</tr>
<tr>
<td>Change</td>
<td>1.24%</td>
<td>7.11%</td>
<td>9.99%</td>
<td>-13.59%</td>
<td>-4.75%</td>
</tr>
</tbody>
</table>

Figure 1-2 Health Index Distribution Comparison
2 Station Switchgear

The following illustrate the changes found for Station Switchgear.

2.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation, however the data sources for “IR Hotspot” and “Dirty” Condition Parameters were changed.

2.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

2.3 Changes in Sample Size
A summary of Population and Sample Size information for Station Switchgear is shown on Table 2-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 2-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Sample Size</td>
</tr>
<tr>
<td>2012</td>
<td>284</td>
<td>33.45%</td>
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<tr>
<td>2014</td>
<td>279</td>
<td>88.89%</td>
</tr>
<tr>
<td>Change</td>
<td>-1.76%</td>
<td>55.44%</td>
</tr>
</tbody>
</table>

![Station Switchgear Sample Size](Figure 2-1 Sample Sizes for 2012 and 2014)
2.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Station Switchgear are shown on Table 2-2 and graphically represented on Figure 2-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>28.42%</td>
<td>34.74%</td>
<td>13.68%</td>
<td>23.16%</td>
</tr>
<tr>
<td>2014</td>
<td>4.84%</td>
<td>36.69%</td>
<td>33.47%</td>
<td>9.27%</td>
<td>15.73%</td>
</tr>
<tr>
<td>Change</td>
<td>4.84%</td>
<td>8.27%</td>
<td>-1.27%</td>
<td>-4.41%</td>
<td>-7.43%</td>
</tr>
</tbody>
</table>

**Table 2-2 Health Index Distribution Summary**

**Station Switchgear Change in Health Index Distribution**

**Figure 2-2 Health Index Distribution Comparison**
3 Air Blast Circuit Breakers

The following illustrate the changes found for Air Blast Circuit Breakers.

3.1 Changes in Health Index Formulation

There were no changes within the Calculator with respect to Health Index formulation.

3.2 Changes in Granularity

There were no changes within the Calculator with respect to granularity.

3.3 Changes in Sample Size

A summary of Population and Sample Size information for Air Blast Circuit Breakers is shown on Table 3-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 3-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>2012</td>
<td>292</td>
</tr>
<tr>
<td>2014</td>
<td>290</td>
</tr>
<tr>
<td>Change</td>
<td>-0.68%</td>
</tr>
</tbody>
</table>

Figure 3-1 Sample Sizes for 2012 and 2014
3.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Air Blast Circuit Breakers are shown on Table 3-2 and graphically represented on Figure 3-2. The results are given in terms of percentage of the total asset population.

Table 3-2 Health Index Distribution Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>3.88%</td>
<td>83.72%</td>
<td>7.75%</td>
<td>4.65%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>3.89%</td>
<td>87.78%</td>
<td>2.78%</td>
<td>5.56%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.01%</td>
<td>4.06%</td>
<td>-4.97%</td>
<td>0.90%</td>
</tr>
</tbody>
</table>

Figure 3-2 Health Index Distribution Comparison
4 Air Magnetic Circuit Breakers

The following illustrate the changes found for Air Magnetic Circuit Breakers.

4.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

4.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

4.3 Changes in Sample Size
A summary of Population and Sample Size information for Air Magnetic Circuit Breakers is shown on Table 4-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>630</td>
<td>46.51%</td>
<td>53.49%</td>
</tr>
<tr>
<td>2014</td>
<td>627</td>
<td>74.32%</td>
<td>25.68%</td>
</tr>
<tr>
<td>Change</td>
<td>-0.48%</td>
<td>27.81%</td>
<td>-27.81%</td>
</tr>
</tbody>
</table>

![Air Magnetic CB Sample Size](Image)

Figure 4-1 Sample Sizes for 2012 and 2014
4.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Air Magnetic Circuit Breakers are shown on Table 4-2 and graphically represented on Figure 4-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>3.07%</td>
<td>57.00%</td>
<td>35.15%</td>
<td>4.78%</td>
</tr>
<tr>
<td>2014</td>
<td>0.21%</td>
<td>4.72%</td>
<td>74.25%</td>
<td>18.88%</td>
<td>1.93%</td>
</tr>
<tr>
<td>Change</td>
<td>0.21%</td>
<td>1.65%</td>
<td>17.25%</td>
<td>-16.27%</td>
<td>-2.85%</td>
</tr>
</tbody>
</table>

Figure 4-2 Health Index Distribution Comparison
5 Oil Circuit Breakers

The following illustrate the changes found for Oil Circuit Breakers.

5.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

5.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

5.3 Changes in Sample Size
A summary of Population and Sample Size information for Oil Circuit Breakers is shown on Table 5-1 “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 5-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Number</th>
<th>Sample Size %</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>398</td>
<td>40.20%</td>
<td>59.80%</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>332</td>
<td>47.29%</td>
<td>52.71%</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>-16.58%</td>
<td>7.09%</td>
<td>-7.09%</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5-1 Sample Sizes for 2012 and 2014**
5.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Oil Circuit Breakers are shown on Table 5-2 and graphically represented on Figure 5-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>HI Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Poor</td>
</tr>
<tr>
<td>2012</td>
<td>1.25%</td>
</tr>
<tr>
<td>2014</td>
<td>0.64%</td>
</tr>
<tr>
<td>Change</td>
<td>-0.61%</td>
</tr>
</tbody>
</table>

![Graph showing changes in Health Index Distribution](image-url)

**Figure 5-2 Health Index Distribution Comparison**
6 Oil KSO Circuit Breakers

The following illustrate the changes found for Oil KSO Circuit Breakers.

6.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

6.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

6.3 Changes in Sample Size
A summary of Population and Sample Size information for Oil KSO Circuit Breakers is shown on Table 6-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 6-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>64</td>
<td>29.69%</td>
</tr>
<tr>
<td>2014</td>
<td>59</td>
<td>37.29%</td>
</tr>
<tr>
<td>Change</td>
<td>-7.81%</td>
<td>7.60%</td>
</tr>
</tbody>
</table>

Figure 6-1 Sample Sizes for 2012 and 2014
6.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Oil KSO Circuit Breakers are shown on Table 6-2 and graphically represented on Figure 6-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>21.05%</td>
<td>52.63%</td>
<td>26.32%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>4.55%</td>
<td>81.82%</td>
<td>13.64%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>-16.51%</td>
<td>29.19%</td>
<td>-12.68%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

**Figure 6-2 Health Index Distribution Comparison**
7 SF6 Circuit Breaker

The following illustrate the changes found for SF6 Circuit Breaker.

7.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

7.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

7.3 Changes in Sample Size
A summary of Population and Sample Size information for SF6 Circuit Breaker is shown on Table 7-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 7-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>240</td>
<td>26.67%</td>
<td>73.33%</td>
</tr>
<tr>
<td>2014</td>
<td>201</td>
<td>32.34%</td>
<td>67.66%</td>
</tr>
<tr>
<td>Change</td>
<td>-16.25%</td>
<td>5.67%</td>
<td>-5.67%</td>
</tr>
</tbody>
</table>

![Table 7-1 Sample Size Summary](image)

**Figure 7-1 Sample Sizes for 2012 and 2014**
7.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for SF6 Circuit Breaker are shown on Table 7-2 and graphically represented on Figure 7-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>1.56%</td>
<td>43.75%</td>
<td>54.69%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.00%</td>
<td>7.69%</td>
<td>46.15%</td>
<td>46.15%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.00%</td>
<td>6.13%</td>
<td>2.40%</td>
<td>-8.53%</td>
</tr>
</tbody>
</table>

**SF6 CB Change in Health Index Distribution**

![Figure 7-2 Health Index Distribution Comparison](image-url)
8 Vacuum Circuit Breakers

The following illustrate the changes found for Vacuum Circuit Breakers.

8.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

8.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

8.3 Changes in Sample Size
A summary of Population and Sample Size information for Vacuum Circuit Breakers is shown on Table 8-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 8-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Sample Size</td>
</tr>
<tr>
<td>2012</td>
<td>546</td>
<td>65.20%</td>
</tr>
<tr>
<td>2014</td>
<td>675</td>
<td>70.81%</td>
</tr>
<tr>
<td>Change</td>
<td>23.63%</td>
<td>5.61%</td>
</tr>
</tbody>
</table>

Figure 8-1 Sample Sizes for 2012 and 2014
8.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Vacuum Circuit Breakers are shown on Table 8-2 and graphically represented on Figure 8-2. The results are given in terms of percentage of the total asset population.

### Table 8-2 Health Index Distribution Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.28%</td>
<td>5.90%</td>
<td>9.27%</td>
<td>84.55%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.21%</td>
<td>3.14%</td>
<td>10.25%</td>
<td>86.40%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>-0.07%</td>
<td>-2.76%</td>
<td>0.98%</td>
<td>1.85%</td>
</tr>
</tbody>
</table>

### Figure 8-2 Health Index Distribution Comparison
9 Submersible Transformers

The following illustrate the changes found for Submersible Transformers.

9.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

9.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

9.3 Changes in Sample Size
A summary of Population and Sample Size information for Submersible Transformers is shown on Table 9-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 9-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>2012</td>
<td>9249</td>
</tr>
<tr>
<td>2014</td>
<td>9554</td>
</tr>
<tr>
<td>Change</td>
<td>3.30%</td>
</tr>
</tbody>
</table>

Figure 9-1 Sample Sizes for 2012 and 2014
9.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Submersible Transformers are shown on Table 9-2 and graphically represented on Figure 9-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.02%</td>
<td>1.33%</td>
<td>20.93%</td>
<td>77.72%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.02%</td>
<td>6.68%</td>
<td>34.93%</td>
<td>58.36%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.00%</td>
<td>5.36%</td>
<td>14.00%</td>
<td>-19.35%</td>
</tr>
</tbody>
</table>

Figure 9-2 Health Index Distribution Comparison
10 **Vault Transformers**

The following illustrate the changes found for Vault Transformers.

**10.1 Changes in Health Index Formulation**

There were no changes within the Calculator with respect to Health Index formulation.

**10.2 Changes in Granularity**

There were no changes within the Calculator with respect to granularity.

**10.3 Changes in Sample Size**

A summary of Population and Sample Size information for Vault Transformers is shown on Table 10-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 10-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>2012</td>
<td>13263</td>
</tr>
<tr>
<td>2014</td>
<td>13034</td>
</tr>
<tr>
<td>Change</td>
<td>-1.73%</td>
</tr>
</tbody>
</table>

**Figure 10-1 Sample Sizes for 2012 and 2014**

---

Thank you for providing the document. I have transcribed the content into a readable format. If you need further assistance or have more questions, feel free to ask!
10.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Vault Transformers are shown on Table 10-2 and graphically represented on Figure 10-2. The results are given in terms of percentage of the total asset population.

### Table 10-2 Health Index Distribution Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.06%</td>
<td>0.39%</td>
<td>18.82%</td>
<td>32.36%</td>
<td>48.37%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.23%</td>
<td>23.48%</td>
<td>39.80%</td>
<td>36.50%</td>
</tr>
<tr>
<td>Change</td>
<td>-0.06%</td>
<td>-0.17%</td>
<td>4.66%</td>
<td>7.44%</td>
<td>-11.87%</td>
</tr>
</tbody>
</table>

### Figure 10-2 Health Index Distribution Comparison
11 Padmounted Transformers

The following illustrate the changes found for Padmounted Transformers.

11.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

11.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

11.3 Changes in Sample Size
A summary of Population and Sample Size information for Padmounted Transformers is shown on Table 11-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 11-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>6950</td>
<td>77.02%</td>
<td>22.98%</td>
</tr>
<tr>
<td>2014</td>
<td>7160</td>
<td>84.55%</td>
<td>15.45%</td>
</tr>
<tr>
<td>Change</td>
<td>3.02%</td>
<td>7.53%</td>
<td>-7.53%</td>
</tr>
</tbody>
</table>

Figure 11-1 Sample Sizes for 2012 and 2014
11.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Padmounted Transformers are shown on Table 11-2 and graphically represented on Figure 11-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.50%</td>
<td>10.54%</td>
<td>88.96%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.02%</td>
<td>10.09%</td>
<td>43.51%</td>
<td>46.38%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.02%</td>
<td>9.59%</td>
<td>32.97%</td>
<td>-42.58%</td>
</tr>
</tbody>
</table>

Figure 11-2 Health Index Distribution Comparison
12 Padmounted Switches

The following illustrate the changes found for Padmounted Switches.

12.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

12.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

12.3 Changes in Sample Size

A summary of Population and Sample Size information for Padmounted Switches is shown on Table 12-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 12-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Sample Size</td>
</tr>
<tr>
<td>2012</td>
<td>793</td>
<td>50.32%</td>
</tr>
<tr>
<td>2014</td>
<td>802</td>
<td>97.01%</td>
</tr>
<tr>
<td>Change</td>
<td>1.13%</td>
<td>46.69%</td>
</tr>
</tbody>
</table>

Table 12-1 Sample Size Summary

![Padmounted Switches Sample Size](image)

Figure 12-1 Sample Sizes for 2012 and 2014
12.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Padmounted Switches are shown on Table 12-2 and graphically represented on Figure 12-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.75%</td>
<td>13.78%</td>
<td>35.09%</td>
<td>50.38%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.39%</td>
<td>7.20%</td>
<td>36.12%</td>
<td>56.30%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>-0.37%</td>
<td>-6.59%</td>
<td>1.03%</td>
<td>5.92%</td>
</tr>
</tbody>
</table>

Figure 12-2 Health Index Distribution Comparison
13 Three Phase Overhead Gang (Manual) Switches

The following illustrate the changes found for Three Phase Overhead Gang (Manual) Switches.

13.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

13.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

13.3 Changes in Sample Size
A summary of Population and Sample Size information for Three Phase Overhead Gang (Manual) Switches is shown on Table 13-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 13-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1069</td>
<td>5.99% 94.01%</td>
</tr>
<tr>
<td>2014</td>
<td>1108</td>
<td>32.94% 67.06%</td>
</tr>
<tr>
<td>Change</td>
<td>3.65%</td>
<td>26.96%</td>
</tr>
</tbody>
</table>

3Φ OH Gang (Man) Switches Sample Size

![Figure 13-1 Sample Sizes for 2012 and 2014](image)
13.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Three Phase Overhead Gang (Manual) Switches are shown on Table 13-2 and graphically represented on Figure 13-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>4.69%</td>
<td>56.25%</td>
<td>39.06%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.01%</td>
<td>63.84%</td>
<td>33.15%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.00%</td>
<td>-1.67%</td>
<td>7.59%</td>
<td>-5.91%</td>
</tr>
</tbody>
</table>

Figure 13-2 Health Index Distribution Comparison
14 Three Phase Overhead Gang (Remote) Switches

The following illustrate the changes found for Three Phase Overhead Gang (Remote) Switches.

14.1 Changes in Health Index Formulation

There were no changes within the Calculator with respect to Health Index formulation.

14.2 Changes in Granularity

There were no changes within the Calculator with respect to granularity.

14.3 Changes in Sample Size

A summary of Population and Sample Size information for Three Phase Overhead Gang (Remote) Switches is shown on Table 14-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 14-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>263</td>
<td>51.71%</td>
<td>48.29%</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>15</td>
<td>86.67%</td>
<td>13.33%</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>-94.30%</td>
<td>34.96%</td>
<td>-34.96%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 14-1 Sample Sizes for 2012 and 2014
14.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Three Phase Overhead Gang (Remote) Switches are shown on Table 14-2 and graphically represented on Figure 14-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>6.62%</td>
<td>63.24%</td>
<td>30.15%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.00%</td>
<td>15.38%</td>
<td>76.92%</td>
<td>7.69%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.00%</td>
<td>8.77%</td>
<td>13.69%</td>
<td>-22.45%</td>
</tr>
</tbody>
</table>

Figure 14-2 Health Index Distribution Comparison
15 **SCADAMATE Switches**

The following illustrate the changes found for SCADAMATE Switches.

15.1 *Changes in Health Index Formulation*

There were no changes within the Calculator with respect to Health Index formulation.

15.2 *Changes in Granularity*

There were no changes within the Calculator with respect to granularity.

15.3 *Changes in Sample Size*

A summary of Population and Sample Size information for SCADAMATE Switches is shown on Table 15-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 15-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>2012</td>
<td>767</td>
</tr>
<tr>
<td>2014</td>
<td>926</td>
</tr>
<tr>
<td>Change</td>
<td>20.73%</td>
</tr>
</tbody>
</table>

![Figure 15-1 Sample Sizes for 2012 and 2014](image-url)
15.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for SCADAMATE Switches are shown on Table 15-2 and graphically represented on Figure 15-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>1.72%</td>
<td>60.86%</td>
<td>37.42%</td>
</tr>
<tr>
<td>2014</td>
<td>0.13%</td>
<td>0.00%</td>
<td>1.14%</td>
<td>57.34%</td>
<td>41.39%</td>
</tr>
<tr>
<td>Change</td>
<td>0.13%</td>
<td>0.00%</td>
<td>-0.58%</td>
<td>-3.52%</td>
<td>3.97%</td>
</tr>
</tbody>
</table>

Figure 15-2 Health Index Distribution Comparison
16 **Wood Poles**

The following illustrate the changes found for Wood Poles.

16.1 **Changes in Health Index Formulation**
There were no changes within the Calculator with respect to Health Index formulation.

16.2 **Changes in Granularity**
There were no changes within the Calculator with respect to granularity.

16.3 **Changes in Sample Size**
A summary of Population and Sample Size information for Wood Poles is shown on Table 16-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>125080</td>
<td>34.91%</td>
<td>65.09%</td>
</tr>
<tr>
<td>2014</td>
<td>123280</td>
<td>37.66%</td>
<td>62.34%</td>
</tr>
<tr>
<td>Change</td>
<td>-1.44%</td>
<td>2.76%</td>
<td>-2.76%</td>
</tr>
</tbody>
</table>

**Table 16-1 Sample Size Summary**

---

**Figure 16-1 Sample Sizes for 2012 and 2014**
16.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Wood Poles are shown on Table 16-2 and graphically represented on Figure 16-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>2.52%</td>
<td>7.67%</td>
<td>46.02%</td>
<td>9.57%</td>
<td>34.22%</td>
</tr>
<tr>
<td>2014</td>
<td>2.34%</td>
<td>7.64%</td>
<td>44.13%</td>
<td>7.28%</td>
<td>38.61%</td>
</tr>
<tr>
<td>Change</td>
<td>-0.18%</td>
<td>-0.04%</td>
<td>-1.89%</td>
<td>-2.29%</td>
<td>4.40%</td>
</tr>
</tbody>
</table>

Figure 16-2 Health Index Distribution Comparison
17 Automatic Transfer Switches

The following illustrate the changes found for Automatic Transfer Switches.

17.1 Changes in Health Index Formulation

There were no changes within the Calculator with respect to Health Index formulation, however the data source for the parameter “Phase Barriers” was changed.

17.2 Changes in Granularity

There were no changes within the Calculator with respect to granularity.

17.3 Changes in Sample Size

A summary of Population and Sample Size information for Automatic Transfer Switches is shown on Table 17-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>70</td>
<td>84.29%</td>
<td>15.71%</td>
</tr>
<tr>
<td>2014</td>
<td>58</td>
<td>91.38%</td>
<td>8.62%</td>
</tr>
<tr>
<td>Change</td>
<td>-17.14%</td>
<td>7.09%</td>
<td>-7.09%</td>
</tr>
</tbody>
</table>

![ATS Sample Size](image)

Figure 17-1 Sample Sizes for 2012 and 2014
17.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Automatic Transfer Switches are shown on Table 17-2 and graphically represented on Figure 17-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3.39%</td>
<td>23.73%</td>
<td>11.86%</td>
<td>35.59%</td>
<td>25.42%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>16.98%</td>
<td>32.08%</td>
<td>30.19%</td>
<td>20.75%</td>
</tr>
<tr>
<td>Change</td>
<td>-3.39%</td>
<td>-6.75%</td>
<td>20.21%</td>
<td>-5.40%</td>
<td>-4.67%</td>
</tr>
</tbody>
</table>

![ATS Change in Health Index Distribution](image)

Figure 17-2 Health Index Distribution Comparison
18 Network Transformers

The following illustrate the changes found for Network Transformers.

18.1 Changes in Health Index Formulation
There were no changes within the Calculator with respect to Health Index formulation.

18.2 Changes in Granularity
There were no changes within the Calculator with respect to granularity.

18.3 Changes in Sample Size
A summary of Population and Sample Size information for Network Transformers is shown on Table 18-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 18-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size Summary</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Sample Size</td>
</tr>
<tr>
<td>2012</td>
<td>1880</td>
<td>98.51%</td>
</tr>
<tr>
<td>2014</td>
<td>1892</td>
<td>99.58%</td>
</tr>
<tr>
<td>Change</td>
<td>0.64%</td>
<td>1.07%</td>
</tr>
</tbody>
</table>

Figure 18-1 Sample Sizes for 2012 and 2014
18.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Network Transformers are shown on Table 18-2 and graphically represented on Figure 18-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.05%</td>
<td>7.99%</td>
<td>34.40%</td>
<td>57.56%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.00%</td>
<td>16.40%</td>
<td>41.45%</td>
<td>42.14%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>-0.05%</td>
<td>8.41%</td>
<td>7.06%</td>
<td>-15.42%</td>
</tr>
</tbody>
</table>

Figure 18-2 Health Index Distribution Comparison
19 **Network Protectors**

Network protectors were assessed in the Kinectrics 2010 standalone assessment for network assets. While it has not been added to the BI Calculator, it is included in the Interim ACA Calculator. The following illustrate the changes found for Network Protectors.

19.1 **Changes in Health Index Formulation**

The Kinectrics 2010 assessment and the 2014 assessment used the same Health Index formulas.

19.2 **Changes in Granularity**

There were no changes within the Calculator with respect to granularity.

19.3 **Changes in Sample Size**

A summary of Population and Sample Size information for Network Protectors is shown on Table 19-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 19-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1479</td>
<td>89.31%</td>
<td>-57.00%</td>
</tr>
<tr>
<td>2014</td>
<td>1615</td>
<td>97.52%</td>
<td>2.48%</td>
</tr>
</tbody>
</table>

**Table 19-1 Sample Size Summary**

**Network Protectors Sample Size**

**Figure 19-1 Sample Sizes for 2012 and 2014**
19.4 Changes in Health Index Classification

A summary of the 2010 and 2014 Health Index distributions for Network Protectors are shown on Table 19-2 and graphically represented on Figure 19-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.90%</td>
<td>27.17%</td>
<td>71.92%</td>
</tr>
<tr>
<td>2014</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.75%</td>
<td>32.25%</td>
<td>64.00%</td>
</tr>
<tr>
<td>Change</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.84%</td>
<td>5.08%</td>
<td>-7.92%</td>
</tr>
</tbody>
</table>

Figure 19-2 Health Index Distribution Comparison
20 **Network Vaults**

The following illustrate the changes found for Network Vaults.

**20.1 Changes in Health Index Formulation**

There were no changes within the Calculator with respect to Health Index formulation.

**20.2 Changes in Granularity**

There were no changes within the Calculator with respect to granularity.

**20.3 Changes in Sample Size**

A summary of Population and Sample Size information for Network Vaults is shown on Table 20-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 20-1. The population and sample size remained fairly constant.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>99.62%</td>
</tr>
<tr>
<td>2012</td>
<td>1061</td>
<td>99.62%</td>
</tr>
<tr>
<td>2014</td>
<td>1062</td>
<td>99.53%</td>
</tr>
<tr>
<td>Change</td>
<td>0.09%</td>
<td>-0.09%</td>
</tr>
</tbody>
</table>

![Network Vaults Sample Size](image)

**Figure 20-1 Sample Sizes for 2012 and 2014**
20.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Network Vaults are shown on Table 20-2 and graphically represented on Figure 20-2. The results are given in terms of percentage of the total asset population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1.14%</td>
<td>5.87%</td>
<td>31.22%</td>
<td>60.93%</td>
<td>0.85%</td>
</tr>
<tr>
<td>2014</td>
<td>1.70%</td>
<td>8.80%</td>
<td>72.37%</td>
<td>16.08%</td>
<td>1.04%</td>
</tr>
<tr>
<td>Change</td>
<td>0.57%</td>
<td>2.93%</td>
<td>41.15%</td>
<td>-44.84%</td>
<td>0.19%</td>
</tr>
</tbody>
</table>

**Figure 20-2 Health Index Distribution Comparison**
21 **Cable Chambers**

The following illustrate the changes found for Cable Chambers.

21.1 **Changes in Health Index Formulation**

There were no changes within the Calculator with respect to Health Index formulation.

21.2 **Changes in Granularity**

There were no changes within the Calculator with respect to granularity.

21.3 **Changes in Sample Size**

A summary of Population and Sample Size information for Cable Chambers is shown on Table 20-1. “Sample Size” and “Insufficient Data for HI” are given in terms of percentage of the total asset population. This information is graphically represented on Figure 20-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Percentage</th>
<th>Insufficient Data for HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>10854</td>
<td>24.30%</td>
<td>75.70%</td>
</tr>
<tr>
<td>2014</td>
<td>10902</td>
<td>35.01%</td>
<td>64.99%</td>
</tr>
<tr>
<td>Change</td>
<td>0.44%</td>
<td>10.72%</td>
<td>-10.72%</td>
</tr>
</tbody>
</table>

**Figure 21-1 Sample Sizes for 2012 and 2014**
21.4 Changes in Health Index Classification

A summary of the 2012 and 2014 Health Index distributions for Cable Chambers are shown on Table 20-2 and graphically represented on Figure 20-2. The results are given in terms of percentage of the total asset population. There was an overall decline in asset condition.

<table>
<thead>
<tr>
<th>Year</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.11%</td>
<td>1.67%</td>
<td>9.40%</td>
<td>43.46%</td>
<td>45.35%</td>
</tr>
<tr>
<td>2014</td>
<td>0.26%</td>
<td>1.60%</td>
<td>10.77%</td>
<td>50.17%</td>
<td>37.20%</td>
</tr>
<tr>
<td>Change</td>
<td>0.15%</td>
<td>-0.07%</td>
<td>1.36%</td>
<td>6.71%</td>
<td>-8.15%</td>
</tr>
</tbody>
</table>

![Cable Chambers Change in Health Index Distribution](image)

**Figure 21-2 Health Index Distribution Comparison**
Appendix B: Glossary of Terms
This page is intentionally left blank.
1. **Asset Condition Assessment (ACA)**
   The purpose of Asset Condition Assessment is to detect and quantify the extent of long-term degradation and to provide a means of quantifying remaining asset life. This includes identifying assets that are either at or near their end-of-life or are at high risk of generalized failure and will require capital expenditures to either refurbish or replace them.

2. **Calculator**
   The Calculator is THESL application that derives the Health Index ratings for applicable distribution, station, and civil assets, based on condition data captured from inspections.

3. **Condition Data Availability**
   An asset’s condition data availability is the ratio of the sum of its maximum scores of available conditions to the sum of its maximum scores for all possible conditions. For example, say an asset has condition parameters A, B, and C with weights of 1, 2, and 3 respectively. Condition parameter factors are rated from 0 through 4, so the maximum factor is 4. The maximum score for a condition parameter is therefore given by (maximum factor)*weight. Thus, for conditions A, B, and C, the maximum scores are $4*1 = 4$, $4*2 = 8$, and $4*3 = 12$ respectively. It follows that the sum of maximum scores for all possible conditions = $4+8+12 = 24$. If asset X only has data for conditions A and B, the sum of maximum scores of available conditions = $4+8 = 12$. Its condition data availability is therefore $12/24 = 50\%$. According to THESL’s 60% Condition Data Availability rule, asset X will not be included in the sample size because its condition data availability is less than 60%. Conversely, if asset Y has data for conditions A and C, its condition data availability = $16/24 = 67\%$, and it will be included in the sample size.

4. **Condition Parameter**
   Condition Parameters are the asset characteristics that are generally related to the long term degradation of the asset. In formulating a Health Index, condition parameters are ranked and evaluated, through the assignment of corresponding weights, based on their contribution to asset degradation. The condition parameter score is an evaluation of an asset with respect to a condition parameter.

   A condition parameter may also be comprised of several sub-condition parameters. For example, a parameter called “Insulation” may be a composite of Oil Quality, DGA, or Winding Doble tests.

5. **Condition Ratings versus Condition Factors**
   For the purposes of formulating a Health Index, numerical values must be assigned to each of the condition parameters available for an asset. THESL assigns scores to parameters during inspections through condition ratings. For a parameter with five levels of condition, for example, THESL uses condition ratings of 1 through 5. This is then translated to condition factors of 4-0. Condition factors are used in the numerical calculation of the Health Index. For example, Factors and Rating can be interpreted as:
### Glossary of Terms

<table>
<thead>
<tr>
<th>THESL Condition Rating</th>
<th>Factors to be Used for Health Indexing</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>Excellent Working condition</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Minor Wear - Working as Required</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Major Wear/Failed - Repaired During Inspection</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Major Wear/Failed - Scheduled Corrective Repair Required</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>Failed - Emergency Repair Required</td>
</tr>
</tbody>
</table>

### 6. Dominant Factor

A dominant factor is asset condition or property that is of such importance that its status will reflect or over-ride the condition of the entire asset. The end of life of this factor can lead to the end of life of the entire asset. For example, for a civil asset, structural elements (e.g. roof, walls, foundation) are of such importance that if they are found to be in, say poor condition, the entire vault is categorized as poor, regardless of the condition of the other parameters.

Dominant factors are often used to de-rate the calculated Health Index of an asset. In the example of a civil asset, the overall Health Index, as it is based on numerous parameters, may be calculated as 70%. Say, however that the foundation is found to be in very poor condition. The Health Index will therefore, be de-rated by 30%, giving an effective Health Index of 0.3*70% = 21%.

### 7. Health Index (HI)

The Health Index quantifies equipment condition by comparing an asset’s Condition Parameters with the Condition Criteria that are measures of the long-term degradation that cumulatively lead to an asset’s end-of-life. Health Indexing differs from maintenance testing whose objective is finding defects and deficiencies that need correction or remediation in order to keep the asset operating prior to reaching its end of life. When using the Health Indexing method it is important to understand the differences between defect management and the resultant unplanned maintenance versus long-term asset condition assessment that evaluates long-term asset degradation leading to its end-of-life.

The Health Index can be used as a tool for assessing the overall health of a complex or relatively simple asset. Distribution assets may consist of several components, e.g. distribution station transformer, or be less complex, e.g. pole mounted transformer. In either case there may be one dominant mode of failure, or there may be several independent failure modes, either for components comprising the asset or for the asset itself. The Health Index combines scores indicating the condition of all of these Condition Parameters into a single indicator of the health of the asset.
8. **Health Index Formulation - Sub-System Definitions**

a) **Insulation**: a sub-system that indicates the overall dielectric status of an asset. This overall status is based on the evaluation of all the involved insulating materials such as insulating oil, polymer, porcelain, or other composite material.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: transformers, breakers, switchgears, and network transformers.

b) **Cooling**: a sub-system that indicates the overall operation temperature status for the asset whose life expectancy is closely correlated to temperature rise. This overall status is based on all the available indications of temperature rise, such as IR scan, temperature monitoring, cooling fluid leakage etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: all types of transformers and switchgear.

c) **Reliability**: a sub-system that indicates the overall probability of failure status for the assets whose statistical failure rate is closely correlated to their operation duration, loading mode or combined effect from multiple independent contributing factors. This overall status is based on the evaluation of all the involved conditions such as age, long-term loading trend and asset overall grading.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: transformers (all types), breakers, switches, and switchgear (all types).

d) **Operating Mechanism**: a sub-system that indicates the overall mechanical operation performance for circuit breakers and switches. This overall status is based on the evaluation of all components and factors that contribute to the mechanical operation, such as linkage, lubrication etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: breakers and switches.

e) **Contact Performance**: a sub-system that indicates the overall status of switching timings and contact degradation, for circuit breakers and switches. This overall status is based on the evaluation of all the switching timings as well as contact surface condition.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: breakers and switches.
f) **Arc Extinction**: a sub-system that indicates the overall status of arc extinguishing mechanism during breaking operation of circuit breakers and switches. This overall status is based on the evaluation of all the components and medium for extinguishing breaking arc, such as oil, gas, vacuum bottle, or the factors that affect arc extinction such as leakage, moisture etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: breakers and switches.

g) **Physical Condition**: a sub-system that indicates the overall status of outer surface defects visible during routine inspection. This overall status is based on the evaluation of the non-critical components to which one has direct access, the factors that might hinder such direct access, or the working environment that might accelerate the deterioration of those components.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: switchgear, distribution transformers, poles and ATS.

h) **Sealing & Connection**: a sub-system that indicates the overall status of physical interfaces among the major components of transformers. This overall status is based on the evaluation of all the component interfaces, such as cable connection, tank gasket etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: station transformers and network transformers.

i) **Control**: a sub-system that indicates the overall status of attached control circuitry for switchgear and ATS. This overall status is based on the evaluation of all the components in control cabinet, such as relay, light, sensor, fuse etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: switchgear and ATS.

j) **Overall**: a sub-system that indicates the overall status of non-electric structures. This overall status is based on the evaluation of all the involved conditions such as age, estimated life and asset overall grading.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: poles, cable chambers and network vaults.

k) **Access**: a sub-system that indicates the overall status of operation convenience and work environment of non-electric structures. This overall status is based on the evaluation of work clearance as well as presence of hazard materials.
The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: cable chambers and network vaults.

l) **Environment:** a sub-system that indicates the overall status of presence of toxic PCB stuff. This overall status is based on the detection of PCB content in distribution transformers.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: distribution transformers.

m) **Switch/Fuse:** a sub-system that indicates the overall status of switches and/or fuses inside switchgear. This overall status is based on the evaluation of the physical conditions of switches and fuses by means of visual inspection.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: all types of switchgear.

n) **Structure:** a sub-system that indicates the overall status of civil structure. This overall status is based on the evaluation of the conditions of roof, walls and floors.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: cable chambers and network vaults.

o) **Mechanical & Electrical:** a sub-system that indicates the overall status of pole characters. This overall status is based on the evaluation of both the mechanical strength and the soil condition.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: different types of poles.

p) **Pole Accessories:** a sub-system that indicates the overall status of pole hardware. This overall status is based on the evaluation of all the hardware attached to poles, such as guy wire, ground etc.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: different types of poles.

q) **Ventilation:** a sub-system that indicates the overall status of structure interior contamination. This overall status is based on the evaluation of all the detrimental findings inside a structure during routine inspection.
The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: cable chambers and network vaults.

r) **Lighting:** a sub-system that indicates the overall status of structure interior lighting, cabling and ducting. This overall status is based on the evaluation of all such components inside a structure during routine inspection.

The Health Index formulation weighting of this sub-system depends on the degradation mechanism of an asset. Assets that employ this sub-system are: cable chambers and network vaults

9. **PDA**
   Portable Data Acquisition devices (PDAs) refer to mobile handsets or ruggedized laptops that enable single-point data entry of maintenance and inspection data for THESL field staff. The use of PDAs is expected to increase the accuracy and timeliness of maintenance and inspection data collected.

10. **Population**
    Population refers to the total number of assets within the asset group.

11. **Sample Size**
    Sample Size refers to number of assets within an asset group that have sufficient condition parameter data for Health Index calculation.

12. **60% Condition Data Availability Rule**
    According to THESL’s 60% Data Availability rule, 60% of an asset’s condition data must be available in order to be included into the sample size.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 43:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 5

THESL indicates it is continuously improving its asset condition inspection data.

a) Please identify the asset classes with significant gaps in industry best practice collection of inspection data.

b) Please provide THESL’s plans to close these gaps.

RESPONSE:

a) Toronto Hydro has not benchmarked its collection of inspection data against industry best practice. Toronto Hydro’s inspection program is in compliance with statutory and regulatory requirements and is based on the Reliability Centered Maintenance (RCM) framework. From 2016 to 2018, Toronto Hydro updated the RCM analyses for each asset class. External engineering services firm METSCO reviewed the analyses and provided compliance documents stating that the analyses were in alignment with RCM best practices.

b) Please refer to the response in part a) above.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 44:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 7, Table 1

a) Please add a column to Table 1 – Recommended Timeline for Intervention.

b) Please compare and contrast the relative meaning of the Health Index Bands H1 to H5 to the previous Health Index categories of very good, good, fair, poor and very poor and recommended timelines for intervention.

c) Please provide THESL’s recommended timeline for intervention for the previous Health Index categories of very good, good, fair, poor and very poor.

RESPONSE:

a) The Asset Condition Assessment (ACA) methodology does not have a numerically defined recommended timeline for intervention. However, the definitions in the table referenced by this interrogatory provide the equivalent level of information regarding the relative urgency of intervention associated with each Health Index Band. It should be noted that the recommended time for intervention associated with Toronto Hydro’s previous ACA methodology was a generalized, high-level guideline based on professional opinion.

b) While in some ways the Health Index Bands in the new and old ACA methodologies are similar, they do not allow for an exact one-to-one comparison. Both
methodologies have five health categories that are intended to track the condition-based probability of failure of an asset, but they are underpinned by different calculations. For the reasons discussed in Exhibit 2B, Section D, Appendix C, Toronto Hydro’s newly developed ACA methodology functions as a more accurate and reliable representation of the relative probability of failure of the utility’s assets. The resulting categorization of the utility’s asset class populations across the five Health Index Bands gives the utility’s planners insight as to condition trends across an asset population and the level of both current and emerging investment needs. In its 2020-2024 Distribution System Plan, Toronto Hydro’s chosen sustainment strategy focusses on maintaining the number of assets in HI4 and HI5 condition in most asset classes, so as to prevent overall asset failure risk from increasing over the period, and to support the sustainment of current reliability performance and other objectives while minimizing price increases. By contrast, a more aggressive risk reduction and performance improvement strategy would see the utility investing more in reducing the number of HI3, HI4 and HI5 assets.

c) For the previous ACA methodology, the recommended timeline for planned replacement of assets was one year for “very poor” condition, 2-3 years for “poor” condition, and 4-10 years for “fair” condition. A recommended timeline for replacement of assets in the “good” and “very good” categories was not defined.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 45:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 8

THESL indicates it retained the U.K. firm EA technology to review its newly developed asset health models, recommended areas for improvement, and provide guidance and training to ensure organizational alignment with the asset management philosophy, principles and practices underpinning the CNAIM approach. Toronto Hydro selected EA Technology for this task as they are the foremost experts in the CNAIM model, having provided support for the development of the original methodology as well as the delivery and implementation of the common models to all U.K. distribution network operators.

a) Please provide a copy of the EA technology report.

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-44 (d) for reports provided by EA Technology.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATOIES

INTERROGATORY 46:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 9

THESL indicates it determined the condition variables for each asset class based on the following criteria: deficiencies that lead to an asset failure; deficiencies that lead to a component of the asset failing; and deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure. The utility performed a comparative analysis of these condition points and assigned appropriate calibration values.

a) Please provide the comparative analysis.

RESPONSE:
Please see Table 1 below for the classification of Toronto Hydro’s condition variables used in deriving Health Scores into deficiencies that lead to an asset failure, deficiencies that lead to a component of the asset failing, and deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure. Please refer to Exhibit 2B, Section D, Appendix C, Pages 26-63 for the calibration values assigned for these condition variables.
### Table 1: Classification of condition variables used in deriving Health Scores.

<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Deficiencies that lead to an asset failure</th>
<th>Deficiencies that lead to a component of the asset failing</th>
<th>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4kV Oil Circuit Breaker</strong></td>
<td>• Insulation resistance deficiency • Oil tank deficiency • Breaker mechanical condition deficiency detected</td>
<td>• Arc extinguishing deficiency • Trip mechanism deficiency • Closing mechanism deficiency • Contact resistance deficiency • Trip free mechanism deficiency • Anti pump operation deficiency • Primary contact deficiency • Arcing contact deficiency • Charging mechanism deficiency</td>
<td>• Corrosion deficiency</td>
</tr>
<tr>
<td><strong>Air Insulated Pad-Mount Switches</strong></td>
<td>• Switch Blade Deficiencies • Arc Suppressors Deficiencies • Phase Barrier Deficiencies • Corrosion Deficiencies • Partial Discharge</td>
<td>• Connections Deficiencies • Grounding Deficiencies</td>
<td>• Hot Spots</td>
</tr>
<tr>
<td><strong>Air Insulated Submersible Switches</strong></td>
<td>• Corrosion Deficiencies • Phase Barrier Deficiencies • Partial Discharge</td>
<td>• Connections Deficiencies • Grounding Deficiencies</td>
<td>• Hot Spots • Internal Flood Water Stains</td>
</tr>
<tr>
<td>Asset Category</td>
<td>Deficiencies that lead to an asset failure</td>
<td>Deficiencies that lead to a component of the asset failing</td>
<td>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</td>
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<td>------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Air Magnetic Circuit Breaker</td>
<td>• Insulation resistance deficiency</td>
<td>• Anti pump operation deficiency</td>
<td>• Corrosion deficiency</td>
</tr>
<tr>
<td></td>
<td>• Breaker mechanical condition deficiency</td>
<td>• Primary contact deficiency</td>
<td>• Pressure Valve deficiency</td>
</tr>
<tr>
<td>Air blast Circuit Breakers</td>
<td>• Insulation resistance deficiency</td>
<td>• Anti pump operation deficiency</td>
<td>• Corrosion deficiency</td>
</tr>
<tr>
<td></td>
<td>• Breaker mechanical condition deficiency</td>
<td>• Primary contact deficiency</td>
<td>• Pressure Valve deficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Arcing contact deficiency</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Arc extinguishing deficiency</td>
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<tr>
<td></td>
<td></td>
<td>• Trip mechanism deficiency</td>
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<tr>
<td></td>
<td></td>
<td>• Closing mechanism deficiency</td>
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<td></td>
<td></td>
<td>• Contact resistance deficiency</td>
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<td></td>
<td></td>
<td>• Contact resistance deficiency</td>
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<tr>
<td></td>
<td></td>
<td>• Corrosion deficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pressure Valve deficiency</td>
<td></td>
</tr>
<tr>
<td>Cable Chamber</td>
<td>• Ducts</td>
<td>• Walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sump Pump</td>
<td>• Floor</td>
<td></td>
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<td></td>
<td>• Drain</td>
<td>• Roof</td>
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<td></td>
<td>• Lid Cover</td>
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<td></td>
<td>• Cable Racking</td>
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<td></td>
<td>• Working Space</td>
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</tr>
<tr>
<td>Asset Category</td>
<td>Deficiencies that lead to an asset failure</td>
<td>Deficiencies that lead to a component of the asset failing</td>
<td>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</td>
</tr>
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<td>----------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| KSO- Oil Circuit Breaker       | • Insulation resistance deficiency  
• Oil tank deficiency  
• Breaker mechanical condition deficiency detected | • Arc extinguishing deficiency  
• Trip mechanism deficiency  
• Closing mechanism deficiency  
• Contact resistance deficiency  
• Trip free mechanism deficiency  
• Anti pump operation deficiency  
• Primary contact deficiency  
• Arcing contact deficiency  
• Charging mechanism deficiency  
• Oil Condition deficiency | • Corrosion deficiency |
| Network Protectors             | | • Deficiencies relating to failure to trip/close | | • Protector Top Condition  
• Internal Flood Water Stains  
• Corrosion Deficiencies  
• Gasket Deficiencies |
| Network Transformers           | • Oil Leak Deficiencies  
• Corrosion Deficiencies  
• Partial Discharge  
• Primary Switch Unit Deficiency | • Connections Deficiencies  
• Grounding Deficiencies | | • Temperature Readings |
<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Deficiencies that lead to an asset failure</th>
<th>Deficiencies that lead to a component of the asset failing</th>
<th>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</th>
</tr>
</thead>
</table>
| Overhead Gang Operated Switch | • Interphase operator Link deficiency  
• Operating Handle deficiency  
• Insulator deficiency  
• Switch Blade deficiency  
• Arc Interrupter deficiency | • Connection Deficiency  
• Ground Connection deficiency  
• Stationary Connect deficiency  
• Switch Base deficiency | • Corrosion Deficiency |
| Pad-Mount Transformers | • Oil Leak Deficiencies  
• Corrosion Deficiencies  
• Partial Discharge | • Connections Deficiencies  
• Grounding Deficiencies | • Temperature Readings |
| SCADAMATE R2 Switch     | • Insulator deficiency  
• Remote operation deficiency  
• Switch operation deficiency | • Switch Base deficiency  
• Ground deficiency | • Corrosion deficiency |
| SF6 Circuit Breaker     | • Insulation resistance deficiency  
• Breaker mechanical condition deficiency | • Closing mechanism deficiency  
• Trip mechanism deficiency  
• Trip free mechanism deficiency  
• Anti pump operation deficiency  
• charging mechanism deficiency  
• SF6 Quality deficiency  
• SF6 Control deficiency  
• SF6 leak | • Corrosion deficiency |
<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Deficiencies that lead to an asset failure</th>
<th>Deficiencies that lead to a component of the asset failing</th>
<th>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>• Contact resistance deficiency</td>
<td></td>
</tr>
<tr>
<td>SF6 Insulated Pad-Mount Switches</td>
<td>• Corrosion Deficiencies</td>
<td>• Connections Deficiencies</td>
<td>• Hot Spots</td>
</tr>
<tr>
<td></td>
<td>• Gas Leak</td>
<td>• Grounding Deficiencies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Partial Discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF6 Insulated Submersible Switches</td>
<td>• Corrosion Deficiencies</td>
<td>• Connections Deficiencies</td>
<td>• Hot Spots</td>
</tr>
<tr>
<td></td>
<td>• Gas Leak</td>
<td>• Grounding Deficiencies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gas Leak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station Power Transformers</td>
<td>• Oil Leak Deficiencies</td>
<td></td>
<td>• Corrosion Deficiencies</td>
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<td>• Oil Tests</td>
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<td>• FFA Tests</td>
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<td>• DGA Tests</td>
</tr>
<tr>
<td>Submersible Transformers</td>
<td>• Oil Leak Deficiencies</td>
<td>• Connections Deficiencies</td>
<td></td>
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<td></td>
<td>• Corrosion Deficiencies</td>
<td>• Grounding Deficiencies</td>
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<tr>
<td></td>
<td>• Corrosion Deficiencies</td>
<td></td>
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<tr>
<td>Underground Vaults</td>
<td>• Duct Deficiencies</td>
<td>• Sump Pump Deficiencies</td>
<td>• Wall Deficiencies</td>
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<tr>
<td></td>
<td>• Drain Deficiencies</td>
<td>• Ventilation Grill Deficiencies</td>
<td>• Floor Deficiencies</td>
</tr>
<tr>
<td></td>
<td>• Hatchway Deficiencies</td>
<td>• Roof Deficiencies</td>
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<tr>
<td>Asset Category</td>
<td>Deficiencies that lead to an asset failure</td>
<td>Deficiencies that lead to a component of the asset failing</td>
<td>Deficiencies that degrade the performance of an asset but do not lead to an immediate asset or component failure</td>
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<td>---------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Vacuum Circuit Breaker | • Insulation resistance deficiency  
• Breaker mechanical condition deficiency  
• Dielectric withstand test Failure.  
• Arc extinguishing deficiency  
• Trip mechanism deficiency  
• Closing mechanism deficiency  
• Contact resistance deficiency  
• Anti pump operation deficiency  
• Primary contact deficiency  
• Arcing contact deficiency  
• Charging mechanism deficiency  
• Corrosion deficiency |                                                                                                               |                                                                                 |
| Vault Transformers   | • Oil Leak Deficiencies  
• Corrosion Deficiencies  
• Connections Deficiencies  
• Grounding Deficiencies |                                                                                                               |                                                                                 |
| Wood Poles           | • Surface Rot at Ground Level  
• Surface Rot Below Ground Level  
• Surface Rot Above Ground Level  
• Pole Decay/Deterioration  
• Shell Thickness  
• Wood Loss  
• Hollow Heart  
• Pocket Present  
• Pole Leaning  
• Bird/Animal Damage  
• Cracks  
• Pole Top Feathering |                                                                                                               |                                                                                 |
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 47:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 9

RCM was critical to Toronto Hydro’s determination of minimum health score limits in CNAIM, known as “collars.” If a deficiency that has a collar is noted during an inspection, the CNAIM algorithm checks to the final health score value is above the collar value. If the value is not above the collar value, then the health score is replaced with the collar value.

Please indicate if THESL has the data on the assets with health scores replaced with the collar value. If yes, please discuss any trends in the data.

RESPONSE:
Assets where health scores are replaced with the collar value account for two percent of Toronto Hydro’s asset population for which a health score was derived. Collars are necessary to prevent masking of critical deficiencies that significantly degrade the asset.

- The asset classes with the lowest proportion of assets for which the health scores were replaced by collars (all under 2 percent) include wood poles, air magnetic and airblast circuit breakers, 4 kV oil circuit breakers, air-insulated submersible switches, and SF6-insulated padmount switches. Below are some of the trends noted:
  - For air-insulated submersible switches, collars replaced the health score for only 1.4 percent of the population, due to minimal to no deficiencies
noted through inspection. These assets are in relatively good condition based on the health score distribution, with the majority of assets in HI1 condition.

- Similar trends were observed for SF6-insulated padmount switches, with collars applied for only 2 percent of the entire population.

- The asset classes with the highest proportion of collars replacing the health score (in the range of 18-23 percent) include KSO oil circuit breakers, air-insulated padmount switches, SF6 circuit breakers, and underground vaults. Below are some of the trends noted:

- The trend for SF6 circuit breakers showed that collars replaced the health scores when critical deficiencies were noted in the inspections. These include, breaker mechanical condition deficiencies (specifically bushing deficiencies), contact resistance deficiencies, and high corrosion in breakers that have an average age of 20 years.

- KSO oil circuit breakers are outdoor assets that are prone to corrosion. Corrosion over time may lead to an oil leak as oil is the insulating material for these circuit breakers. The collars for corrosion deficiencies replaced the health scores and these breakers were categorised in the HI3 health index band.

- For air-insulated padmount switches, trends show that one of the following deficiencies were noted which led to the collars being applied to replace the health score. These deficiencies include: Partial Discharge, Switch blade deficiencies, Phase Barrier deficiencies, and Enclosure corrosion.

- For underground vaults, the data trend showed that roof deficiencies replaced the health scores with collar values and that resulted in the assets
to fall in either HI2 or HI3 health index bands, depending on the level of
deterioration of the deficiency.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 48:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 10, Table 2

a) Please confirm the vintage of the data.

b) Please identify key assets beyond underground cables and pole top transformers that are not included in Table 2.

c) Please identify the assets where age is the only determinant of condition.

d) Please add the following Columns to Table 1: “Asset Population”; “% Availability of Condition Data”; “Number of asset in very poor/poor condition from EB-2014-0116”.

e) Please provide an excel version of Table 2.

RESPONSE:

a) The ACA results were calculated using inspections data from up to the end of 2017.

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (b).

c) There are no asset classes in Table 2 for which age is the only determinant of condition.
d) The question referenced Table 1, which seems to be in error. Toronto Hydro assumed that the question is referring to Table 2 in Exhibit 2B, Section D, Appendix C for the purpose of this response. Please see Table 1 below for “% of Availability of Condition data”, “Asset Population” and “Number of asset in very poor/poor condition from EB-2014-0116”. Please note that “% of Availability of Condition data” “Number of Assets in Poor and Very Poor condition from EB-2014-0016” in the old ACA methodology do not have a one to one comparison with the new ACA methodology. Please refer to Toronto Hydro’s response to interrogatory 2B-AMPCO-44 for more details.

Table 1: Summary of Current and Past Health Distribution with Asset Population and Condition Data Availability.

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>HI1</th>
<th>HI2</th>
<th>HI3</th>
<th>HI4</th>
<th>HI5</th>
<th>Asset Pop.</th>
<th>% of Availability of Condition Data</th>
<th>From EB 2014-0116</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Head Gang Operated Switches</td>
<td>854</td>
<td>27</td>
<td>76</td>
<td>3</td>
<td>9</td>
<td>969</td>
<td>94%</td>
<td>-</td>
</tr>
<tr>
<td>SCADAMATE Switches</td>
<td>1,084</td>
<td>1</td>
<td>26</td>
<td>-</td>
<td>8</td>
<td>1,119</td>
<td>58%</td>
<td>-</td>
</tr>
<tr>
<td>Wood Pole</td>
<td>68,425</td>
<td>5,777</td>
<td>20,915</td>
<td>10,877</td>
<td>1,074</td>
<td>107,068</td>
<td>78%</td>
<td>3,560</td>
</tr>
<tr>
<td>4kV Oil Circuit Breaker (MS)</td>
<td>36</td>
<td>4</td>
<td>123</td>
<td>24</td>
<td>-</td>
<td>187</td>
<td>83%</td>
<td>16</td>
</tr>
<tr>
<td>KSO Circuit Breakers (TS)</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>11</td>
<td>1</td>
<td>40</td>
<td>95%</td>
<td>1</td>
</tr>
<tr>
<td>SF6 Circuit Breakers (TS)</td>
<td>130</td>
<td>6</td>
<td>18</td>
<td>3</td>
<td>3</td>
<td>160</td>
<td>79%</td>
<td>-</td>
</tr>
<tr>
<td>Vacuum Circuit Breaker (MS &amp; TS)</td>
<td>578</td>
<td>46</td>
<td>13</td>
<td>2</td>
<td>29</td>
<td>668</td>
<td>64%</td>
<td>1</td>
</tr>
<tr>
<td>Air Magnetic Circuit Breaker (MS &amp; TS)</td>
<td>145</td>
<td>90</td>
<td>247</td>
<td>21</td>
<td>53</td>
<td>556</td>
<td>92%</td>
<td>22</td>
</tr>
<tr>
<td>Airblast Circuit Breaker (MS &amp; TS)</td>
<td>15</td>
<td>9</td>
<td>206</td>
<td>1</td>
<td>3</td>
<td>234</td>
<td>82%</td>
<td>7</td>
</tr>
<tr>
<td>Station Power Transformers</td>
<td>83</td>
<td>77</td>
<td>61</td>
<td>13</td>
<td>8</td>
<td>242</td>
<td>97%</td>
<td>33</td>
</tr>
<tr>
<td>Network Transformers</td>
<td>1,334</td>
<td>255</td>
<td>166</td>
<td>60</td>
<td>7</td>
<td>1,822</td>
<td>99%</td>
<td>-</td>
</tr>
<tr>
<td>Network Protectors</td>
<td>1,086</td>
<td>185</td>
<td>319</td>
<td>74</td>
<td>26</td>
<td>1,690</td>
<td>99%</td>
<td>-</td>
</tr>
<tr>
<td>Cable Chambers</td>
<td>8,112</td>
<td>1,162</td>
<td>1,350</td>
<td>398</td>
<td>89</td>
<td>11,111</td>
<td>86%</td>
<td>61</td>
</tr>
<tr>
<td>Submersible Transformers</td>
<td>7,816</td>
<td>588</td>
<td>271</td>
<td>172</td>
<td>55</td>
<td>8,902</td>
<td>90%</td>
<td>-</td>
</tr>
<tr>
<td>Air-Insulated Padmount Switches</td>
<td>404</td>
<td>20</td>
<td>73</td>
<td>30</td>
<td>45</td>
<td>572</td>
<td>100%</td>
<td>3</td>
</tr>
<tr>
<td>Vault Transformers</td>
<td>6,807</td>
<td>4,315</td>
<td>450</td>
<td>214</td>
<td>45</td>
<td>11,831</td>
<td>95%</td>
<td>23</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>Asset Class</th>
<th>HI1</th>
<th>HI2</th>
<th>HI3</th>
<th>HI4</th>
<th>HI5</th>
<th>Asset Pop.</th>
<th>% of Availability of Condition Data¹</th>
<th>From EB 2014-0116</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Vaults (combined)</td>
<td>1,017</td>
<td>186</td>
<td>72</td>
<td>12</td>
<td>29</td>
<td>1,316</td>
<td>99%</td>
<td>N/A</td>
</tr>
<tr>
<td>ATS Vaults</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>100%</td>
<td>N/A</td>
</tr>
<tr>
<td>CLD Vaults</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>21</td>
<td>96%</td>
<td>N/A</td>
</tr>
<tr>
<td>CRD Vaults</td>
<td>9</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>90%</td>
<td>N/A</td>
</tr>
<tr>
<td>Network Vaults</td>
<td>322</td>
<td>120</td>
<td>63</td>
<td>11</td>
<td>29</td>
<td>545</td>
<td>100%</td>
<td>93</td>
</tr>
<tr>
<td>Submersible Switch Vaults</td>
<td>115</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>120</td>
<td>78%</td>
<td>N/A</td>
</tr>
<tr>
<td>URD Vaults</td>
<td>542</td>
<td>61</td>
<td>8</td>
<td>1</td>
<td>-</td>
<td>612</td>
<td>100%</td>
<td>N/A</td>
</tr>
<tr>
<td>Padmount Transformers</td>
<td>5,547</td>
<td>656</td>
<td>283</td>
<td>113</td>
<td>18</td>
<td>6,617</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>SF6-Insulated Padmount Switches</td>
<td>402</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>410</td>
<td>100%</td>
<td>N/A</td>
</tr>
<tr>
<td>SF6 Insulated Submersible Switches</td>
<td>353</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>19</td>
<td>396</td>
<td>90%</td>
<td>N/A</td>
</tr>
<tr>
<td>Air Insulated Submersible Switches</td>
<td>755</td>
<td>79</td>
<td>27</td>
<td>7</td>
<td>-</td>
<td>868</td>
<td>84%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note 1: Please note that % of Availability of Condition data is calculated as per Toronto Hydro’s implementation of the CNAIM methodology.

1 e) Please see Appendix A for an excel version of Table 2.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 49:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 11, Table 3

a) Please add the following Columns to Table 3: “Asset Population”; % Availability of Condition Data” if different than Table 2.

b) Please provide an excel version of Table 3.

RESPONSE:

a) The columns “Asset Population”, “% Availability of Condition Data” provided in Toronto Hydro’s response to interrogatory 2B-AMPCO-48 (d) are not different from Table 3.

b) Please see Appendix A for an excel version of Table 3.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 50:
Reference(s): Exhibit 2B, Section D, Appendix C, p. 12

Over time, THESL has made minor adjustments to asset useful life values (i.e. minimum expected useful life, maximum expected useful life, and typical useful life for each asset class type) based on utility experience, but has not performed a full review of its useful values (including review of the derivation methodology) since the Kinectrics study performed in 2010. THESL intends to update its useful life values and age-based probability of failure curves in the future.

a) Please provide THESL’s current asset useful life values in comparison to Kinectrics.

b) Please indicate when THESL plans to update its useful life values.

RESPONSE:

a) As explained in response to interrogatory 1B-CCC-12, Toronto Hydro’s Useful Life for each system asset class/type is equivalent to the Mean Useful Life derived from the Useful Life Ranges provided in the Kinectrics study, “Toronto Hydro-Electric System Useful Life of Assets”. The only exceptions to this are as follows:

• UG Primary Cable – Direct Buried (DB) Jacketed: The Kinectrics study results in a Mean Useful Life of 23 years for direct buried cables but does not differentiate

1 Toronto Hydro has provided a copy of this report as Appendix A to the response to interrogatory 2B-SEC-38.
between Jacketed and Unjacketed direct buried cables, nor differentiate between
XLPE and TRXLPE cables. Based upon Toronto Hydro’s understanding of the
vintages and installations of these cables, all unjacketed direct-buried cables are
assumed to be of the XLPE type, and therefore align to this 23 year mean useful
life. However, jacketed direct-buried cables are assumed to be of the TRXLPE
type, and these cables will possess a longer useful life due to the tree-retardant
properties and improved manufacturing processes associated with these cables.
Therefore, Toronto Hydro has adopted a useful life of 40 years for jacketed direct-
buried cables, which represents the Typical Useful Life for XLPE cable in Conduit as
per the Kinectrics study in order to be conservative.

- Stations – DC Batteries: The Mean Useful Life for DC Batteries derived from the
  Kinectrics study is 20 years. However, based on failure data, Toronto Hydro
determined that a Useful Life of 10 years is more appropriate.

- Meters: Smart Meters were not included in the Kinectrics study. Toronto Hydro
  uses a useful life of 15 years based on the 2010 Asset Depreciation Study
  conducted by Kinectrics for the Ontario Energy Board.²

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (d).

² Kinectrics Inc., Asset Depreciation Study for the Ontario Energy Board (July 8, 2010), available at: <
https://www.oeb.ca/oeb/_Documents/EB-2010-0178/Kinetics-418033-OEB%20Asset%20Amortization-
%20Final%20Rep.pdf>.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 51:

Reference(s): Exhibit 2B, Section D, Appendix C, p. 3

THESL indicates asset age is also typically a significant factor in the calculation of HI scores, partly due to the fact that age bears a strong statistical relationship with the probability of failure. The extent to which a utility can monitor significant degradation characteristics that are predictive of asset failure varies depending on the type of asset. Even when the utility is able to monitor a number of condition variables that are strongly predictive of an asset’s remaining life, it remains necessary to include age as an ACA variable.

a) Please discuss directionally how the results of the ACA would differ if age was not used as an ACA variable.

RESPONSE:

a) As explained throughout Exhibit 2B, Section D, Appendix C, Toronto Hydro’s ACA methodology depends on age to calculate the Initial Health Score of an asset. This score is then modified by condition data to arrive at the Current Health Score of the asset. Therefore, age is a necessary input in the calculation of the health score for an asset.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 52:
Reference(s): Exhibit 2B

Please complete the excel spreadsheet 2B-AMPCO-52.

RESPONSE:
Please see the Excel spreadsheet entitled “2B-AMPCO-52.xlsx”. Please also see 2B-SEC-51 and all notes referenced therein, which apply to 2B-AMPCO-52.xls. In addition, Toronto Hydro does not have forecasts for asset population in 2020.
# Assets Replaced

<table>
<thead>
<tr>
<th>Asset Class</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
<th># units replaced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2B-AMPCO-52</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref: 2B-D-Appendix C P64 Table C1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Assets Replaced</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 Air Insulated Submersible Switches</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>2 SF-6 Insulated Submersible Switches</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3 SF-6 Insulated Padmount Switches</strong></td>
<td>802</td>
<td>47</td>
<td>79</td>
<td>87</td>
<td>43</td>
<td>41</td>
<td><strong>13 Air Insulated Padmount Switches</strong></td>
<td>49</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td><strong>5 URD Vaults</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>6 Submersible Switch Vaults</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7 Network Vaults</strong></td>
<td>1062</td>
<td>34</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td><strong>8 CRD Vaults</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>9 CLD Vaults</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>10 ATS Vaults</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>11 Underground Vaults (combined)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>12 Padmount Transformers</strong></td>
<td>7160</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13 Submersible Transformers</strong></td>
<td>13034</td>
<td>105</td>
<td>710</td>
<td>740</td>
<td>310</td>
<td>296</td>
<td><strong>14 Submersible Transformers</strong></td>
<td>9554</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>15 Cable Chambers</strong></td>
<td>10902</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>16 Network Protectors</strong></td>
<td>1615</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td><strong>17 Network Transformers</strong></td>
<td>1892</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>18 Station Power Transformers</strong></td>
<td>268</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>19 Air Blast Circuit Breaker (MS &amp; TS)</strong></td>
<td>290</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td><strong>20 Air Magnetic Circuit Breaker (MS &amp; TS)</strong></td>
<td>627</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>21 Vacuum Circuit Breaker (MS &amp; TS)</strong></td>
<td>675</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td><strong>22 SF6 Circuit Breakers (TS)</strong></td>
<td>201</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>23 KSO Circuit Breaker</strong></td>
<td>59</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>11</td>
<td>6</td>
<td><strong>24 4kV Oil Circuit Breaker (MS)</strong></td>
<td>332</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>25 Wood Pole</strong></td>
<td>123280</td>
<td>10283</td>
<td>4550</td>
<td></td>
<td></td>
<td></td>
<td><strong>26 SCADAMATE Switches</strong></td>
<td>926</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>27 Overhead Gang Operated Switches</strong></td>
<td>1123</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>28 Underground Cable</strong></td>
<td>12920</td>
<td>1062</td>
<td></td>
</tr>
<tr>
<td><strong>29 Pole Mounted Transformer</strong></td>
<td>30700</td>
<td>940</td>
<td>769</td>
<td>441</td>
<td>575</td>
<td>290</td>
<td><strong>31 Overhead Cables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Population EB-2014-0116**

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Population EB-2014-0116**

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>407</td>
<td>380</td>
<td>380</td>
<td>387</td>
<td>387</td>
</tr>
</tbody>
</table>

---

**Population EB-2020-0118**

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>109.6</td>
<td>110.4</td>
<td>110.4</td>
<td>115.1</td>
<td>115.1</td>
</tr>
</tbody>
</table>

---

**Population EB-2019-0116**

<table>
<thead>
<tr>
<th>Year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 53:

Reference(s): Exhibit 2B

Please complete the excel spreadsheet 2B-AMPCO-53.

RESPONSE:

Please see the Excel spreadsheet entitled “2B-AMPCO-53.xlsx”. A deficiency for the purposes of this response refers to the number of deficiencies reported through Toronto Hydro’s Preventative and Predictive Maintenance programs (Exhibit 4A, Tab 2, Schedules 1-3).
**2B-AMPCO-53**  
Ref: 2B-D-Appendix C P64 Table C1

# Deficiencies from Preventative & Predictive Maintenance programs

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Air Insulated Submersible Switches</td>
<td>289</td>
<td>247</td>
<td>167</td>
<td>145</td>
</tr>
<tr>
<td>2 SF-6 Insulated Submersible Switches</td>
<td>148</td>
<td>117</td>
<td>108</td>
<td>67</td>
</tr>
<tr>
<td>3 SF-6 Insulated Padmount Switches</td>
<td>52</td>
<td>159</td>
<td>214</td>
<td>226</td>
</tr>
<tr>
<td>4 Padmount Transformers (incl. Pad)</td>
<td>1,754</td>
<td>2,910</td>
<td>3,845</td>
<td>3,173</td>
</tr>
<tr>
<td>5 URD Vaults</td>
<td>325</td>
<td>743</td>
<td>1,153</td>
<td>964</td>
</tr>
<tr>
<td>6 Submersible Switch Vaults</td>
<td>30</td>
<td>18</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>7 Network Vaults</td>
<td>3,385</td>
<td>4,276</td>
<td>5,644</td>
<td>7,719</td>
</tr>
<tr>
<td>8 CRD Vaults</td>
<td>18</td>
<td>38</td>
<td>88</td>
<td>34</td>
</tr>
<tr>
<td>9 CLD Vaults</td>
<td>9</td>
<td>19</td>
<td>125</td>
<td>55</td>
</tr>
<tr>
<td>10 ATS Vaults</td>
<td>37</td>
<td>28</td>
<td>23</td>
<td>36</td>
</tr>
<tr>
<td>11 Underground Vaults (combined)</td>
<td>4,537</td>
<td>5,571</td>
<td>9,262</td>
<td>11,016</td>
</tr>
<tr>
<td>12 Vault Transformers</td>
<td>4,189</td>
<td>3,890</td>
<td>3,357</td>
<td>3,869</td>
</tr>
<tr>
<td>13 Air Insulated Padmount Switches</td>
<td>337</td>
<td>351</td>
<td>556</td>
<td>421</td>
</tr>
<tr>
<td>14 Submersible Transformers</td>
<td>2,878</td>
<td>2,219</td>
<td>2,251</td>
<td>1,592</td>
</tr>
<tr>
<td>15 Cable Chambers (As of October 2018)</td>
<td>1,707</td>
<td>2,640</td>
<td>2,321</td>
<td>1,198</td>
</tr>
<tr>
<td>16 Network Protectors</td>
<td>503</td>
<td>512</td>
<td>407</td>
<td>429</td>
</tr>
<tr>
<td>17 Network Transformers</td>
<td>497</td>
<td>508</td>
<td>557</td>
<td>645</td>
</tr>
<tr>
<td>18 Station Power Transformers</td>
<td>525</td>
<td>380</td>
<td>368</td>
<td>239</td>
</tr>
<tr>
<td>19 Air Blast Circuit Breaker (MS &amp; TS)</td>
<td>7</td>
<td>11</td>
<td>36</td>
<td>6</td>
</tr>
<tr>
<td>20 Air Magnetic Circuit Breaker (MS &amp; TS)</td>
<td>114</td>
<td>79</td>
<td>115</td>
<td>75</td>
</tr>
<tr>
<td>21 Vacuum Circuit Breaker (MS &amp; TS)</td>
<td>17</td>
<td>133</td>
<td>42</td>
<td>22</td>
</tr>
<tr>
<td>22 Sf6 Circuit Breakers (TS)</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>32</td>
</tr>
<tr>
<td>23 KSO Circuit Breaker</td>
<td>5</td>
<td>12</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>24 4kV Oil Circuit Breaker (MS)</td>
<td>16</td>
<td>32</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>25 Wood Pole</td>
<td>256</td>
<td>417</td>
<td>215</td>
<td>93</td>
</tr>
<tr>
<td>26 SCADAMATE Switches</td>
<td>60</td>
<td>8</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>27 Overhead Gang Operated Switches</td>
<td>225</td>
<td>136</td>
<td>52</td>
<td>20</td>
</tr>
<tr>
<td>28 Underground Cable</td>
<td>92</td>
<td>121</td>
<td>335</td>
<td>401</td>
</tr>
<tr>
<td>29 Pole Mounted Transformer</td>
<td>30</td>
<td>38</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>
PPENDIXRESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO INTERROGATORIES

INTERROGATORY 54:

Reference(s): Exhibit 2B, Section E6.1

a) Page 17 Figure 11: Please provide the Historical Reliability of Feeders Proposed for Conversion in Figure 11 in terms of Average Outage Duration Excluding Major Event Days.

b) Page 17: Please provide the number of outages (excluding MEDs) for each of the years 2012 to 2017 and 2018 to date, for the 4.16kV Downtown Core compared to each of the 4.16kV and 13.8kV Systems.

c) Page 18: Please provide the total number of Box Construction assets i.e. transformers, switches and poles.

d) Page 18: Please provide the number of Box Construction assets i.e. transformers, switches and poles with a Health Index Score of HI4 and HI5.

e) Page 20: For Rear Lot Conversion, please provide the number of forecast customer conversions compared to actuals for each of the years 2015 to 2019.

f) Page 20: For Rear Lot Conversion, please provide the number of forecast customer conversions for each of the years 2020 to 2024.
g) Page 23 Table 10: For each of the Rear Lot Projects please provide the Station and Feeder.

h) Page 23 Table 10: For each of the planned rear lot area projects, please provide the assets to be replaced by asset class.

i) Page 23 Table 10: For each of the 8 rear lot areas in Table 10, please provide the number of PCB at-risk transformers.

j) Please provide the total number of planned rear lot conversion projects completed for the years 2015 to 2018 compared to planned.

k) For each of the years 2015 to 2018, please provide an excel spreadsheet that sets out the planned Rear Lot projects from EB-2014-0116 that includes Project Number, Project Name, Forecast Cost ($M), Forecast Start Date and Forecast Completion Date compared to the Actual Cost, Actual Start Date and Actual Completion Date.

l) In part (k) please identify and explain all planned projects that were cancelled or deferred.

m) In Part (k) please identify any new projects added for the 2016 to 2019 period.

RESPONSE:

a) Please see Figure 1 below for average outage duration excluding MEDs of feeders proposed for conversion through the box construction projects.
Figure 1: Average Outage Duration Excluding for Proposed Box Construction Projects

b) Table 1 below sets out the number of outages per year excluding MEDs (2012 to 2018) for the 4.16 kV Downtown Core compared to the 4.16 kV and 13.8 kV systems.

Table 1: Number of outages excluding MEDs for 4.16 kV Downtown Core and 4.16kV and 13.8 kV systems.

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.16kV Downtown Core Outages</td>
<td>42</td>
<td>41</td>
<td>28</td>
<td>27</td>
<td>27</td>
<td>19</td>
<td>39</td>
</tr>
<tr>
<td>All 4.16kV System Outages</td>
<td>198</td>
<td>293</td>
<td>241</td>
<td>190</td>
<td>169</td>
<td>186</td>
<td>206</td>
</tr>
<tr>
<td>13.8kV System Outages</td>
<td>219</td>
<td>243</td>
<td>262</td>
<td>244</td>
<td>232</td>
<td>216</td>
<td>223</td>
</tr>
</tbody>
</table>

c) Table 2 below sets out the total count of box construction assets by asset type.

Table 2: Box Construction Asset Counts

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Unit Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td>3784</td>
</tr>
<tr>
<td>Switches</td>
<td>1875</td>
</tr>
</tbody>
</table>
Table 3 below sets out the count of box construction assets with a Health Index score of HI4 or HI5. As noted in Exhibit 2B, Section D, Appendix C, page 12, assets such as pole top transformers do not have inspection programs that provide enough data to form a complete ACA. It should be noted that functional obsolescence is the trigger driver for the Box Construction Conversion segment. More specifically, the segment is designed to mitigate public and employee safety risks posed by these legacy and aging assets. Please see Exhibit 2B, Section, E6.1.3.2 for a discussion of the drivers of the segment.

Table 3: Box construction assets with HI4 or HI5

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>HI4 or HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td>N/A¹</td>
</tr>
<tr>
<td>Switches</td>
<td>3²</td>
</tr>
<tr>
<td>UG Conductor (KM)</td>
<td>N/A¹</td>
</tr>
<tr>
<td>OH Conductor (KM)</td>
<td>N/A¹</td>
</tr>
<tr>
<td>Poles</td>
<td>422</td>
</tr>
</tbody>
</table>

1 No ACA score available.
2 Out of 67 assets with ACA score available.

e) Table 4 below sets out the number of forecast customer conversions compared to actuals for 2015. Toronto Hydro did not establish 2016-2019 forecasts by customer count.
Table 4: Forecast versus actual customer conversions for 2015.

<table>
<thead>
<tr>
<th>Customers Converted</th>
<th>Forecasted</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>702</td>
<td>778</td>
</tr>
</tbody>
</table>

f) Table 5 below sets out the number of rear lot customers that are forecast to be converted from 2020 to 2024.

Table 5: Forecast number of rear lot customer converted 2020-2024

<table>
<thead>
<tr>
<th>Forecast number of rear lot customers to be converted</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>66</td>
<td>618</td>
<td>558</td>
<td>535</td>
<td>637</td>
</tr>
</tbody>
</table>

g) Table 6 below sets out the station and feeder for each rear lot project.

Table 6: Project stations and feeders

<table>
<thead>
<tr>
<th>Project</th>
<th>Station</th>
<th>Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAMESTOWN</td>
<td>ALBION MS</td>
<td>MGF1</td>
</tr>
<tr>
<td></td>
<td>WATERCLIFFE MS</td>
<td>UAF3</td>
</tr>
<tr>
<td>KINGSVIEW</td>
<td>BLACKFRIAR MS</td>
<td>VCF1</td>
</tr>
<tr>
<td>RICHVIEW PARK</td>
<td>DALEGROVE MS</td>
<td>RCF1</td>
</tr>
<tr>
<td></td>
<td>DUNSANY MS</td>
<td>JDF2</td>
</tr>
<tr>
<td>MOUNT OLIVE</td>
<td>DELAMERE MS</td>
<td>PFF3</td>
</tr>
<tr>
<td>MARTIN GROVE GARDENS</td>
<td>DUNSANY MS</td>
<td>JDF2</td>
</tr>
<tr>
<td></td>
<td>HIGHBURY MS</td>
<td>TAF2</td>
</tr>
<tr>
<td>WILLOWRIDGE</td>
<td>FIELDGATE MS</td>
<td>MLF4</td>
</tr>
<tr>
<td></td>
<td>RICHVIEW TS</td>
<td>88M46</td>
</tr>
<tr>
<td>THORNCREST</td>
<td>LONGFIELD MS</td>
<td>BHF1</td>
</tr>
<tr>
<td></td>
<td>RAVENSBORNE MS</td>
<td>ABF2</td>
</tr>
<tr>
<td>MARKLAND WOODS</td>
<td>MILL MS</td>
<td>LFF2</td>
</tr>
<tr>
<td></td>
<td>NEILSON DR MS</td>
<td>BAF4</td>
</tr>
</tbody>
</table>
h) Table 7 below sets out the volume of assets (by asset type) to be replaced as part of each rear lot project.

<table>
<thead>
<tr>
<th>Asset Type</th>
<th># of Units or Conductor Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jamestown</strong></td>
<td></td>
</tr>
<tr>
<td>Cable</td>
<td>5.9</td>
</tr>
<tr>
<td>UG Switch</td>
<td>5</td>
</tr>
<tr>
<td>UG Transformer</td>
<td>34</td>
</tr>
<tr>
<td><strong>Kingsview</strong></td>
<td></td>
</tr>
<tr>
<td>Pole</td>
<td>3</td>
</tr>
<tr>
<td>Conductor</td>
<td>1.9</td>
</tr>
<tr>
<td>Cable</td>
<td>0.6</td>
</tr>
<tr>
<td>UG Switch</td>
<td>1</td>
</tr>
<tr>
<td>OH Transformer</td>
<td>10</td>
</tr>
<tr>
<td>UG Transformer</td>
<td>3</td>
</tr>
<tr>
<td><strong>Markland Woods</strong></td>
<td></td>
</tr>
<tr>
<td>Pole</td>
<td>42</td>
</tr>
<tr>
<td>Conductor</td>
<td>2.6</td>
</tr>
<tr>
<td>Cable</td>
<td>2.3</td>
</tr>
<tr>
<td>OH Transformer</td>
<td>23</td>
</tr>
<tr>
<td>UG Transformer</td>
<td>2</td>
</tr>
<tr>
<td><strong>Martin Grove Gardens</strong></td>
<td></td>
</tr>
<tr>
<td>Pole</td>
<td>8</td>
</tr>
<tr>
<td>Conductor</td>
<td>5.1</td>
</tr>
<tr>
<td>Cable</td>
<td>1.5</td>
</tr>
<tr>
<td>OH Switch</td>
<td>3</td>
</tr>
<tr>
<td>OH Transformer</td>
<td>28</td>
</tr>
<tr>
<td>UG Transformer</td>
<td>3</td>
</tr>
<tr>
<td><strong>Mount Olive</strong></td>
<td></td>
</tr>
<tr>
<td>Cable</td>
<td>0.8</td>
</tr>
<tr>
<td>UG Transformer</td>
<td>8</td>
</tr>
<tr>
<td><strong>Richview Park</strong></td>
<td></td>
</tr>
<tr>
<td>Pole</td>
<td>3</td>
</tr>
<tr>
<td>Conductor</td>
<td>1.9</td>
</tr>
<tr>
<td>Cable</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 7: Project Asset Replacements
Table 8 below sets out the number of PCB at-risk transformers for each of the eight rear lot areas.

Table 8: PCB at-risk transformers in rear lot areas

<table>
<thead>
<tr>
<th>Rear Lot Area</th>
<th>At Risk PCB Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorncrest</td>
<td>16</td>
</tr>
<tr>
<td>Jamestown</td>
<td>26</td>
</tr>
<tr>
<td>Markland Woods</td>
<td>8</td>
</tr>
<tr>
<td>Martin Grove Gardens</td>
<td>21</td>
</tr>
<tr>
<td>Mount Olive</td>
<td>8</td>
</tr>
<tr>
<td>Kingsview</td>
<td>5</td>
</tr>
<tr>
<td>Richview Park</td>
<td>13</td>
</tr>
<tr>
<td>Willowridge</td>
<td>4</td>
</tr>
</tbody>
</table>

Based on the 2015-2019 DSP, Exhibit 2B, Section E6.6.6.1, pages 31-32 (see “Proposed Work Plan”), 2015-2019 projects were presented at the station level (instead of as
individual projects). Table 9 below compares planned versus actual projects (electrical phase) by station for 2015-2018:

**Table 9: Planned versus actual projects by station for 2015-2018**

<table>
<thead>
<tr>
<th>Year</th>
<th>Planned</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Mill MS</td>
<td>Mill MS</td>
</tr>
<tr>
<td></td>
<td>Dalegrove MS</td>
<td>Rosethorn MS</td>
</tr>
<tr>
<td></td>
<td>Warden TS</td>
<td>Dearham Galloway MS</td>
</tr>
<tr>
<td></td>
<td>Livingston Guildwood MS</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Mill MS</td>
<td>Mill MS</td>
</tr>
<tr>
<td></td>
<td>Dalegrove MS</td>
<td>Rexdale MS</td>
</tr>
<tr>
<td></td>
<td>Warden TS</td>
<td>Warden TS</td>
</tr>
<tr>
<td></td>
<td>Chaplain MS</td>
<td>Dearham Galloway MS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Livingston Guildwood MS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Longfield MS</td>
</tr>
<tr>
<td>2017</td>
<td>Mill MS</td>
<td>Warden TS</td>
</tr>
<tr>
<td></td>
<td>Dalegrove MS</td>
<td>Mill MS</td>
</tr>
<tr>
<td></td>
<td>Chaplain MS</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>Mill MS</td>
<td>Longfield MS</td>
</tr>
<tr>
<td></td>
<td>Neilson MS</td>
<td>Dalegrove MS</td>
</tr>
<tr>
<td></td>
<td>Longfield MS</td>
<td></td>
</tr>
</tbody>
</table>

k) Appendix A to this response sets out the requested information for the planned 2015 projects that were proposed in EB-2014-0116. Please note that only 2015 projects were specified in the 2015-2019 DSP. The data in the appendix is based on in-service additions.

l) There were no cancellations or deferrals in relation to any of the projects listed under part (k) above.

---

3 EB-2014-0116, Exhibit 2B, Section E6.6, p. 37, Table 12.
m) As discussed in part (j) above, the 2015-2019 DSP presented a plan for 2016-2019 at a station level. For the differences between planned and actual projects at the station level for the period of 2016 to 2018, please refer to part (j) above. Table 10 below lists projects for 2019, comparing what was planned in the 2015-2019 DSP to the most recent plan.

Table 10: Planned versus actual 2019 projects

<table>
<thead>
<tr>
<th>Year</th>
<th>2015-2019 Plan</th>
<th>Updated Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>Mill MS</td>
<td>Mill MS</td>
</tr>
<tr>
<td></td>
<td>Longfield MS</td>
<td>Longfield MS</td>
</tr>
<tr>
<td></td>
<td>Ravensbourne MS</td>
<td>Rexdale MS</td>
</tr>
<tr>
<td>Project Number</td>
<td>Project Name</td>
<td>Forecast Cost</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>---------------</td>
</tr>
<tr>
<td>E11382</td>
<td>E11382 Livingston/Guild Rear Lot VC (SCGGF1) - Phase 3</td>
<td>3.17</td>
</tr>
<tr>
<td>W15210</td>
<td>W15210 P07-Markland Wood Ph4b Rear Lot Conversion-Electrical ETLLFF4</td>
<td>1.18</td>
</tr>
<tr>
<td>W15211</td>
<td>W15211 P07-Markland Wood Rear Lot Conversion PH4c-Electrical ETLLFF4</td>
<td>1.21</td>
</tr>
</tbody>
</table>
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 55:

Reference(s): Exhibit 2B

Please complete the following table to show the number of projects by year:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear Lot Conversion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box Construction Conversion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESPONSE:

The following table provides a preliminary estimate of the number of projects Toronto Hydro expects to complete in each year of the 2020-2024 plan for these segments. These figures correspond with the prioritized plans shown in Exhibit 2B, Section E6.1, Tables 10 and 12.

Table 1: Number of Projects in the Area Conversion Segments

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear Lot Conversion</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Box Construction Conversion</td>
<td>9</td>
<td>12</td>
<td>17</td>
<td>14</td>
<td>24</td>
<td>15</td>
<td>11</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 56:

Reference(s): Exhibit 2B, Section E6.4

a) Page 6: Please provide the number of ATS and RPB units replaced in 2018 and 2019.

b) Page 11 Figure 6: Please explain how THESL determined its forecast of 102 HI4 units and 165 HI5 units by 2024.

c) Page 15: Please provide the number of network vaults replaced in 2018 and 2019.

d) Page 23: THESL plans to spend $5.1 million to replace 13 units in 2020 to 2014. In 2018 to 2019, THESL expects to spend $3.2 million to replace 26 units. Please explain the increase in unit costs over the test period.

e) Page 28: Please provide the forecast cost of Option 1 for Legacy Network Equipment Renewal.

f) Page 28: Please provide the number of ATS and RPB units replaced on a reactive basis over the 2015 to 2018 period.

g) Page 29: Please provide the number of network units replaced on a reactive basis over the 2015 to 2018 period.
RESPONSE:

a) The forecast ATS and RPB replacements are 18 in 2018 and seven in 2019, for a total of 25.¹

b) A detailed methodology of how future HI scores are determined can be found in Exhibit 2B Distribution System Plan; Section D Asset Management Process; Appendix C Toronto Hydro Asset Condition Assessment Methodology.

c) The table below shows Toronto Hydro’s expected volume of unit completion for the Network Vault Renewal segment. Network vault replacements would be the Vault Rebuild row of this table.

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vault Rebuild</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Roof Rebuild</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Vault Decommission</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1: Network Vault Renewal Expected Unit Volume for 2018 and 2019

d) The 25 ATS and RPB replacements over the 2018-2019 period includes several projects that were almost entirely constructed in 2017, but were commissioned, and therefore counted, in 2018. In addition, the projects planned for 2018-2019 are the simplest of the remaining ATS and RPB projects. This is to achieve the greatest safety and reliability gains at earliest opportunity in the program. The 13 remaining replacements for the 2020-2024 period are the most complex, with the largest scope

¹ In Exhibit 2B, Section E6.4, at page 23, Toronto Hydro stated that 26 units are forecast for replacement in 2018-2019. In preparing the response to 2B-SEC-61, Toronto Hydro discovered that a 2017 unit had been counted as a 2018 unit due to a drafting error. The correct figure for 2018-2019 is 25, and the correct figure for 2015-2017 is 15.
of work, and therefore most expensive projects.

e) A typical cost for a reactive replacement of ATS or RPB cannot be provided. Costs vary widely as repairs likely involve overtime hours, variable repair costs for other civil and electrical assets damaged during the ATS or RPB failure, variable replacement equipment costs depending upon individual customer requirements, and other site specific requirements.

f) Between 2015 and 2017, a total of four ATSs and RPBs were reactively replaced. Data for 2018 is not yet available.

g) Between 2015 and 2017, 127 network units were reactively replaced. Data for 2018 is not yet available.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 57:

Reference(s): Exhibit 2B, Section E6.5

a) Page 5 Figure 2: Please add 2018 data to Figure 2.

b) Page 6 Table 4: Please provide the asset population for each of the asset categories in Table 4 as of 2017 and forecast for 2024.

c) Page 6 Table 5: Please provide the condition of wood poles in 2015.

d) Page 8 Figure 4: Please define forced outages.

e) Page 8: Please provide the number of pole transformer failures for each of the years 2013 to 2018.

f) Page 11 Figure 9: Of the 6,400 transformers that contain or are at risk of containing PCBs, please provide the confirmed number of overhead transformers that contain PCBs.

g) Page 11: Of the overhead transformers confirmed with PCBs in part k), please provide the number leaking oil.
h) Page 14: Please provide the number of pole failures for each of the years 2013 to 2018.

i) Page 14: Please provide the reactive work requests for pole accessories for the years 2013 to 2018.

j) Page 14: Please provide the number of pole accessory failures for each of the years 2013 to 2018.

k) Page 16: Please provide the number of switch failures for each of the years 2013 to 2018.

l) Page 16: Please provide the number of HI4 switches and HI5 switches.

m) Page 18 Table 7: For each of the asset classes in Table 7, please provide the number of HI4 and HI5 assets to be replaced.

n) Page 19: Please provide the number of Voltage Conversion projects, Feeder Rebuild projects, and Spot Replacements for each of the years 2013 to 2018 and forecast for each of the years 2019 to 2024.

o) Page 20: Please provide the cost of Option #1.

p) Page 21: Please provide the cost of Option #3.
RESPONSE:

a) 2018 reliability results are not available at this time.

b) Please see the asset populations in the table below.

Table 1: Asset Populations

<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Asset Type</th>
<th>Population in 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td>Wood</td>
<td>107,000</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>61,000</td>
</tr>
<tr>
<td>Transformers</td>
<td>Overhead</td>
<td>30,100</td>
</tr>
<tr>
<td>Switches</td>
<td>Overhead Gang</td>
<td>2,700</td>
</tr>
<tr>
<td></td>
<td>In-Line Disconnect</td>
<td>4,900</td>
</tr>
</tbody>
</table>

Toronto Hydro does not forecast material changes to the overall population of poles, overhead transformers, or overhead switches between 2017 and 2024.

c) Please see the table below.

Table 2: Health Index Data of Wood Poles in 2015

<table>
<thead>
<tr>
<th>Condition Band</th>
<th># of Wood Poles</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI1</td>
<td>63,074</td>
</tr>
<tr>
<td>HI2</td>
<td>5,065</td>
</tr>
<tr>
<td>HI3</td>
<td>27,956</td>
</tr>
<tr>
<td>HI4</td>
<td>6,032</td>
</tr>
<tr>
<td>HI5</td>
<td>718</td>
</tr>
</tbody>
</table>

d) A forced outage is an outage that is not planned and that lasts for at least one minute in duration.
e) Please refer to Toronto Hydro’s response to interrogatory 2B-AMPCO-35.

f) Of the 6,400 transformers, 1,414 are confirmed to contain PCBs.

g) Zero of the 1,414 transformers referenced in part (f) are leaking oil. Transformers leaking oil are reactively replaced when discovered. (See generally Exhibit 2B, Section 6.7.)

h) Please refer to Toronto Hydro’s response to interrogatory 2B-AMPCO-35.

i) Please see the table below.

Table 3: 2013-2018 Reactive Work Requests for Pole Accessories

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Work Requests</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>351</td>
</tr>
<tr>
<td>2014</td>
<td>279</td>
</tr>
<tr>
<td>2015</td>
<td>274</td>
</tr>
<tr>
<td>2016</td>
<td>220</td>
</tr>
<tr>
<td>2017</td>
<td>284</td>
</tr>
<tr>
<td>2018</td>
<td>214</td>
</tr>
</tbody>
</table>

j) Please see (i). Toronto Hydro does not separately track the number of pole accessory failures.

k) Please refer to Toronto Hydro’s response to interrogatory 2B-AMPCO-35.

l) Please see the table below.
Table 4: Switches (HI4 and HI5)

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Asset Condition Data in 2017</th>
<th>Asset Condition Data in 2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HI4</td>
<td>HI5</td>
</tr>
<tr>
<td>Switches</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>

Please note that the table does not include in-line switches. Toronto Hydro does not have a health index for Overhead in-line disconnect switches. These assets are inspected as part of Overhead Line Patrols as described in the Preventative and Predictive Overhead Line Maintenance program (Exhibit 4A, Tab 2, Schedule 1), however, the patrols do not collect the requisite data to conduct an asset condition assessment.

m) Please see the table below.

Table 5: Health Index (HI) - Assets planned for Replacement in 2019

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>HI for Assets Planned for 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HI4</td>
</tr>
<tr>
<td>Wood Poles</td>
<td>159</td>
</tr>
<tr>
<td>Switches</td>
<td>0</td>
</tr>
</tbody>
</table>

Please note that as described in part (l), Toronto Hydro does not calculate health indices for all switches, and for similar reasons, for overhead transformers and conductors. Furthermore, projects (and project schedules) have not been developed for 2020-2024 and as a result the table above only contains health index information for 2019.

n) Please see the table below for 2013-2019. Specific projects and project schedules have not been developed for 2020-2024.
Table 6: Voltage Conversion, Feeder Rebuilds & Spot Replacement Projects (2013 – 2019)

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Replacement</td>
<td>8</td>
</tr>
<tr>
<td>Voltage Conversion</td>
<td>6</td>
</tr>
<tr>
<td>Feeder Rebuild</td>
<td>9</td>
</tr>
</tbody>
</table>

1 Please note that 2018 and 2019 are forecast numbers.

o) Toronto Hydro estimates that Option 1 would cost approximately $195 million.

p) Please refer to Exhibit 2B, Section E6.5, Page 22 for the cost of Option 3.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 58:

Reference(s): Exhibit 2B, Section E6.6

a) Page 5 Table 4: Please add a column that shows the % of Assets in HI4 or H15 condition.

b) Page 9 Table 5: Please provide the Health Index rating for each TS Switchgear proposed for replacement. Please provide the Health Index rating for each TS Switchgear from EB-2014-0116.

c) Page 9 Table 6: Please add a column that shows the % of Assets in HI4 or H15 condition at the end of 2024 without investment.

d) Page 11 Table 7: Please add a column that shows the % of Assets in HI4 or H15 condition.

e) Page 14 Table 8: Please provide the Health Index rating for each TS Outdoor Breaker proposed for replacement. Please provide the Health Index for each TS Outdoor Breaker rating from EB-2014-0116.

f) Page 18 Table 10: Please provide the Health Index rating for each TS Outdoor Switch proposed for replacement. Please provide the Health Index for each TS Outdoor Switch rating from EB-2014-0116.
g) Page 20 Table 11: Please provide the Health Index rating for each MS Switchgear proposed for replacement. Please provide the Health Index for each MS Switchgear rating from EB-2014-0116.

h) Page 23 Table 12: Please provide the Health Index rating for each Power Transformer proposed for replacement. Please provide the Health Index for each Power Transformer rating from EB-2014-0116.

i) Page 26 Table 13: Please provide the Health Index rating for each MS Primary Supply proposed for replacement.

j) Page 30 Table 15: Please add a column that shows the % of Assets in HI4 or H15 condition.

k) Page 31: THESL plans to replace 14 DACSAN RTUs, 15 MOSCAD RTUs, and 10 D20 RTU’s over the 2020-2024 period. Please provide the Health Index rating for each RTU.

l) Page 40 Table 21: Please add a column that shows the % of Assets in HI4 or H15 condition.

m) Page 30 Table 15: Please provide the Health Index rating for each RTU.

n) Page 42 Table 22: Please provide the Health Index rating for each SST Proposed Replacement.
RESPONSE:

a) Toronto Hydro does not calculate health scores for switchgear. Toronto Hydro produces health scores for circuit breakers, a switchgear component. Please refer to Exhibit 2B, Section E6.6, Page 7, Figure 3 for more information on circuit breaker condition.

b) See response to part (a) regarding the calculation of health scores for switchgear.

Table 1 below provides the number of circuit breakers in each health band for the TS switchgear proposed for replacement during the 2020-2024 period, and Table 2 provides those from EB-2014-0116.

Table 1: Health Score of Circuit Breakers inside TS Switchgear Proposed for Replacement during 2020-2024

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>HI1</th>
<th>HI2</th>
<th>HI3</th>
<th>HI4</th>
<th>HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strachan TS</td>
<td>A5-6T</td>
<td></td>
<td></td>
<td>11</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Carlaw TS</td>
<td>A4-5E</td>
<td></td>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windsor TS</td>
<td>A5-6WR</td>
<td></td>
<td></td>
<td>11</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Duplex TS</td>
<td>A1-2DX</td>
<td>1</td>
<td>9</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bridgman TS</td>
<td>A1-2H</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Health Score of Circuit Breakers inside TS Switchgear from EB-2014-0116

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>HI1</th>
<th>HI2</th>
<th>HI3</th>
<th>HI4</th>
<th>HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlaw TS</td>
<td>A6-7E</td>
<td></td>
<td></td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wiltshire TS</td>
<td>A3-4W</td>
<td></td>
<td></td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strachan TS</td>
<td>A7-8T</td>
<td></td>
<td></td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplex TS</td>
<td>A5-6DX</td>
<td></td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Panel: Distribution System Capital and Maintenance

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Number of Circuit Breakers (as of 2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hi1</td>
</tr>
<tr>
<td><strong>Windsor TS</strong></td>
<td>A5-6WR</td>
<td>-</td>
</tr>
<tr>
<td><strong>Wiltshire TS</strong></td>
<td>A5-6W</td>
<td>-</td>
</tr>
<tr>
<td><strong>Main TS</strong></td>
<td>A1-2MN</td>
<td>11</td>
</tr>
<tr>
<td><strong>Windsor TS</strong></td>
<td>A3-4WR</td>
<td>-</td>
</tr>
<tr>
<td><strong>Strachan TS</strong></td>
<td>A5-6T</td>
<td>-</td>
</tr>
</tbody>
</table>

1. c) See response to part (a).

2. d) Please see Table 3 below.

### Table 3: TS Outdoor Breaker Demographics at the end of 2019

<table>
<thead>
<tr>
<th>Outdoor Breaker Technology</th>
<th># of Assets</th>
<th>% of Assets Past Useful Life</th>
<th>% of Assets with PCBs&gt;2ppm</th>
<th>% of Assets in HI4 and HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSO Oil Circuit Breaker</td>
<td>20</td>
<td>20%</td>
<td>85%</td>
<td>30%</td>
</tr>
<tr>
<td>SF6 Circuit Breaker</td>
<td>25</td>
<td>0%</td>
<td>N/A</td>
<td>16%</td>
</tr>
<tr>
<td>Vacuum Circuit Breaker</td>
<td>45</td>
<td>0%</td>
<td>N/A</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>4%</td>
<td>19%</td>
<td>11%</td>
</tr>
</tbody>
</table>

3. e) Table 4 provides the health scores for TS Outdoor Breakers proposed for replacement during the 2020-2024 period, and Table 5 provides those from EB-2014-0116. Please note that health scores are only one of many factors considered when selecting the breakers proposed for replacement, as stated in Exhibit 2B, Section E6.6:

   “These breakers have been selected using a variety of inputs including current condition assessment, asset age, projected condition in 2024, load served, and PCB content. All of the breakers proposed for replacement will be beyond their 45-year useful life expectancy and contain or are at risk of containing oil with PCBs”. 

---

Panel: Distribution System Capital and Maintenance
### Table 4: Health Score for TS Outdoor Breakers Proposed for Replacement in 2020-2024

<table>
<thead>
<tr>
<th>Station</th>
<th>Feeder</th>
<th>Health Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairchild TS</td>
<td>M10</td>
<td>HI4</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M26</td>
<td>HI2</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M23</td>
<td>HI3</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M26</td>
<td>HI2</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M29</td>
<td>HI1</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M30</td>
<td>HI1</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M32</td>
<td>HI1</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M23</td>
<td>HI1</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M32</td>
<td>HI1</td>
</tr>
</tbody>
</table>

### Table 5: Health Score for TS Outdoor Breakers from EB-2014-0116

<table>
<thead>
<tr>
<th>Station</th>
<th>Feeder</th>
<th>Health Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermondsey TS</td>
<td>M1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bermondsey TS</td>
<td>M9</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bermondsey TS</td>
<td>M11</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M24</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M4</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M2</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M27</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M31</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M25</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M27</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M21</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M28</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Fairchild TS</td>
<td>M2</td>
<td>HI4</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M30</td>
<td>HI1</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M30</td>
<td>HI3</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M10</td>
<td>HI4</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M22</td>
<td>HI3</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M23</td>
<td>HI3</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M24</td>
<td>HI2</td>
</tr>
<tr>
<td>Station</td>
<td>Feeder</td>
<td>Health Score</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M31</td>
<td>HI3</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M32</td>
<td>HI3</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M29</td>
<td>HI3</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M26</td>
<td>HI2</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M29</td>
<td>HI1</td>
</tr>
<tr>
<td>Leslie TS</td>
<td>M32</td>
<td>HI1</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M30</td>
<td>HI4</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M7</td>
<td>HI4</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M9</td>
<td>HI4</td>
</tr>
<tr>
<td>Rosscowan Pharmacy MS</td>
<td>SCJG52T1</td>
<td>HI4</td>
</tr>
<tr>
<td>Fairchild TS</td>
<td>M10</td>
<td>HI4</td>
</tr>
<tr>
<td>Fairchild TS</td>
<td>M22</td>
<td>HI3</td>
</tr>
<tr>
<td>Fairchild TS</td>
<td>M4</td>
<td>HI4</td>
</tr>
<tr>
<td>Finch TS</td>
<td>M23</td>
<td>HI3</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M3</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Bathurst TS</td>
<td>M5</td>
<td>N/A - Replacement Completed</td>
</tr>
</tbody>
</table>

1) Toronto Hydro does not calculate health scores for its TS Outdoor Switches.

2) See response to part (a) regarding switchgear health scores.

3) Table 6 below provides the number of circuit breakers in each health band for the MS switchgear proposed for replacement during the 2020-2024 period, and Table 7 provides those from EB-2014-0116.
Table 6: Health Score of Circuit Breakers inside MS Switchgear Proposed for Replacement during 2020-2024

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Number of Circuit Breakers (as of 2017)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacy CPR MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Rosethorne MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Thistletown MS</td>
<td>T1-T2SG</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Browns Line MS</td>
<td>T1-T2SG</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Galloway Dearhamwoods MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Neilson Dr MS</td>
<td>T1-T2SG</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Highbury MS</td>
<td>T1-T2SG</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Watercliffe MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bellamy Eglinton MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Midland Lawrence MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Brimley Seminole MS</td>
<td>T1SG</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ravensbourne MS</td>
<td>T1SG</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 7: Health Score of Circuit Breakers inside MS Switchgear from EB-2014-0116

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Number of Circuit Breakers (as of 2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porterfield MS</td>
<td>T1-T2SG</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Neilson Dr MS</td>
<td>T1-T2SG</td>
<td>-</td>
</tr>
<tr>
<td>Thornton MS</td>
<td>T1-T2SG</td>
<td>6</td>
</tr>
<tr>
<td>Islington MS</td>
<td>T1-T2SG</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Brian Elinor MS</td>
<td>T1SG</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Brimley Bernadine MS</td>
<td>T1SG</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Greencedar Lawrence MS</td>
<td>T1SG</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Scarborough Civic Centre (YMCA)</td>
<td>1035TV</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Lawrence Scarborough Golf Club MS</td>
<td>T2SG</td>
<td>N/A - Replacement Completed</td>
</tr>
</tbody>
</table>
h) The health scores of the power transformers proposed for replacement are provided in Table 8 below, and those from EB-2014-0116 are provided in Table 9. Nine of the ten power transformers proposed for the 2020-2024 period are projected to have health scores of at least material deterioration (i.e. HI3 or worse) by 2024. Furthermore, health scores are only one of many factors considered when selecting the power transformers proposed for replacement, as stated in Exhibit 2B, Section E6.6:

“[…], in addition to condition, Toronto Hydro also considers age, loading, PCB concentration in oil\(^1\), and failure impact to prioritize its replacements”

### Table 8: Health Score of Power Transformers Proposed for Replacement during 2020-2024

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Health Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brimley Shaddock MS</strong></td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td><strong>Pharmacy CPR MS</strong></td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td><strong>Belfield MS</strong></td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td><strong>Galloway Dearhamwoods MS</strong></td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td><strong>Burlingame MS</strong></td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td><strong>Highbury MS</strong></td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td><strong>Bellamy Eglinton MS</strong></td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td><strong>Brimley Bernadine MS</strong></td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td><strong>Humber Bay MS</strong></td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td><strong>Windsor MS</strong></td>
<td>TR1</td>
<td>HI3</td>
</tr>
</tbody>
</table>

\(^1\) All power transformers are tested for PCBs with each of their oil tests, which occur annually.
Table 9: Health Score of Power Transformers from EB-2014-0116

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Health Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellamy Lawrence MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Blaketon MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Brian Elinor MS</td>
<td>TR1</td>
<td>HI1</td>
</tr>
<tr>
<td>Brimley Bernadine MS</td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td>Canadian Rd Birchmount MS</td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td>Centennial MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Coronation Bennett MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Flemingdon MS TR1</td>
<td>TR1</td>
<td>HI4</td>
</tr>
<tr>
<td>Greencedar Lawrence MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>High Level MS</td>
<td>TR2</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Lawrence Kennedy MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Lawrence Scar Golf Club Rd MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Midland Lawrence MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>Norseman MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Oberon MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Pharmacy CPR MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Redcliff MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Redcliff MS</td>
<td>TR2</td>
<td>HI3</td>
</tr>
<tr>
<td>Rosscowan Pharmacy MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Sentinel MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Taysham MS</td>
<td>TR1</td>
<td>HI2</td>
</tr>
<tr>
<td>Underwriters Crouse MS</td>
<td>TR1</td>
<td>HI3</td>
</tr>
<tr>
<td>York MS</td>
<td>TR1</td>
<td>N/A - Replacement Completed</td>
</tr>
<tr>
<td>York MS</td>
<td>TR2</td>
<td>N/A - Replacement Completed</td>
</tr>
</tbody>
</table>

i) Toronto Hydro does not calculate health scores for its MS primary supplies. The MS primary supply is a combination of multiple assets, rather than a single asset. Its major assets include: primary cable, primary disconnect switches, and primary circuit breakers. Toronto Hydro does not produce health scores for cable, or the air-insulated primary disconnect switches, which are typically used in Toronto Hydro’s MS primary
supplies. However, Toronto Hydro produces health scores for its circuit breakers.

Referring to Exhibit 2B, Section E6.6, Page 26, Table 13, the only MS primary supply listed that uses a primary circuit breaker is the Centennial D’Arcy Magee MS primary supply. This circuit breaker has a health score of HI3.

j) Toronto Hydro does not produce health scores for its stations Remote Terminal Units (RTUs).

k) See response to (j) above.

l) Toronto Hydro does not produce health scores for its Station Service Transformers (SSTs).

m) See response to (j) above.

n) See response to (l) above.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 59:
Reference(s): Exhibit 2B, Section E6.7, p. 1

a) Please provide the number of asset failures addressed for each of the years 2015 to 2018.

b) Please provide the number of high risk asset deficiencies addressed for each of the years 2015 to 2018.

RESPONSE:

a) Please refer to Table 1 for the number of Work Requests for each of the years 2015-2018. As described in Exhibit 2B, Section E6.7.3.2, and in particular on page 9, lines 1-2, Work Requests address both asset failures and high risk asset deficiencies. Toronto Hydro is unable to distinguish between these two sources of Work Requests.

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive Capital Work Requests</td>
<td>1,842</td>
<td>1,622</td>
<td>1,748</td>
<td>1,875</td>
</tr>
</tbody>
</table>

b) Please see part (a).
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 60:

Reference(s): Exhibit 2B, Section E6.7, p. 4, Table 4

<table>
<thead>
<tr>
<th>Asset</th>
<th>Customer Interruptions (Cl)</th>
<th>Customer Hours Interrupted (CHI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Switches</td>
<td>805</td>
<td>359</td>
</tr>
<tr>
<td>Overhead Transformers</td>
<td>190</td>
<td>112</td>
</tr>
<tr>
<td>Poles</td>
<td>770</td>
<td>739</td>
</tr>
<tr>
<td>Underground Cables</td>
<td>756</td>
<td>729</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>302</td>
<td>292</td>
</tr>
</tbody>
</table>

a) Please provide the number of Cl and CHI by asset in Table 4 for each of the years 2015 to 2018.

b) Please confirm Poles includes pole hardware. If yes, please separate the Cl and CHI results in Table 4 for poles and pole hardware.

c) Please rank the assets in Table 4 in terms of criticality when they fail.

d) For each asset type in Table 4, please provide the percentage in HI4 or HI5.

e) Please provide the Cl and CHI for each of the years 2015 to 2018 for the Secondary Network.
RESPONSE:

a) Please see the Customer Interruption (CI) and Customer Hours Interrupted (CHI) in Table 1 and Table 2 below.

Table 1: 2015 – 2018 Customer Interruptions (CI)

<table>
<thead>
<tr>
<th>Asset</th>
<th>2015 CI</th>
<th>2016 CI</th>
<th>2017 CI</th>
<th>2018 CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Switches</td>
<td>34,413</td>
<td>28,612</td>
<td>27,736</td>
<td>31,766</td>
</tr>
<tr>
<td>Overhead Transformers</td>
<td>14,698</td>
<td>3,008</td>
<td>16,203</td>
<td>2,617</td>
</tr>
<tr>
<td>Poles</td>
<td>18,576</td>
<td>1,632</td>
<td>537</td>
<td>4,243</td>
</tr>
<tr>
<td>Underground Cables</td>
<td>167,854</td>
<td>156,387</td>
<td>138,659</td>
<td>132,845</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>18,414</td>
<td>29,195</td>
<td>41,417</td>
<td>30,188</td>
</tr>
</tbody>
</table>

Table 2: 2015 – 2018 Customer Hours Interrupted (CHI)

<table>
<thead>
<tr>
<th>Asset</th>
<th>2015 CHI</th>
<th>2016 CHI</th>
<th>2017 CHI</th>
<th>2018 CHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Switches</td>
<td>18,392</td>
<td>18,276</td>
<td>9,889</td>
<td>17,162</td>
</tr>
<tr>
<td>Overhead Transformers</td>
<td>4,935</td>
<td>2,857</td>
<td>11,027</td>
<td>5,532</td>
</tr>
<tr>
<td>Poles</td>
<td>14,684</td>
<td>1,741</td>
<td>2,217</td>
<td>4,032</td>
</tr>
<tr>
<td>Underground Cables</td>
<td>137,398</td>
<td>187,565</td>
<td>148,215</td>
<td>114,804</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>20,572</td>
<td>20,042</td>
<td>27,890</td>
<td>20,586</td>
</tr>
</tbody>
</table>

b) The Customers Interrupted (CI) and Customer Hours Interrupted (CHI) for poles in Table 4 does not include pole hardware.

c) Toronto Hydro does not rank criticality on the basis of asset class alone. The criticality will depend on a variety of factors such as the location of the asset on a feeder, potential restoration time, and number of customers connected. For example, a switch located on a lateral of the feeder supplying a subdivision will be lower in criticality than a switch on the main trunk of the feeder supplying multiple subdivisions.
d) Table 4 below indicates the 2017 Health Index of the respective assets.

Table 4: Assets at HI4 and HI5

<table>
<thead>
<tr>
<th>Asset</th>
<th>HI4</th>
<th>HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Switches</td>
<td>0.14%</td>
<td>0.81%</td>
</tr>
<tr>
<td>Poles</td>
<td>10.16%</td>
<td>1.00%</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>1.92%</td>
<td>0.43%</td>
</tr>
<tr>
<td>Overhead Transformers</td>
<td>N/A 1</td>
<td></td>
</tr>
<tr>
<td>Underground Cables</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

1 Toronto Hydro’s Asset Condition Assessment (ACA) does not currently include data for these asset categories.

e) Toronto Hydro does not currently have separate reliability data for its secondary networks.
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 61:

Reference(s): Exhibit 2B, Section E6.7, p. 8, Figure 3

Please complete the following table to show the source of Reactive Capital Deficiencies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventative &amp; Predictive Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Operations &amp; Customer Communications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESPONSE:

Toronto Hydro issues work requests to address deficiencies as part of the Reactive Capital program. Table 1 below shows the number of Reactive Capital work requests created by source to address deficiencies.

Table 1: Reactive Capital Work Requests by Source for 2013-2018

<table>
<thead>
<tr>
<th># Work Requests</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventative &amp; Predictive Maintenance</td>
<td>78</td>
<td>166</td>
<td>558</td>
<td>711</td>
<td>900</td>
<td>1063</td>
</tr>
<tr>
<td>Field Operations &amp; Customer Communications</td>
<td>712</td>
<td>616</td>
<td>514</td>
<td>447</td>
<td>410</td>
<td>443</td>
</tr>
<tr>
<td>Emergency Response</td>
<td>594</td>
<td>754</td>
<td>770</td>
<td>464</td>
<td>438</td>
<td>422</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1384</td>
<td>1536</td>
<td>1842</td>
<td>1622</td>
<td>1748</td>
<td>1875</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 62:
Reference(s): Exhibit 2B, Section E6.7, p. 9, Figure 4

a) Please provide the values for the number of work requests for underground, overhead and station work and the totals for each year 2013 to 2018.

b) Please provide the number of work requests for the secondary network.

c) Please provide a breakdown of the number of underground assets replaced by asset type for each of the years 2013 to 2018.

d) Please provide a breakdown of the number of overhead assets replaced by asset type for each of the years 2013 to 2018.

e) Please provide a breakdown of the number of station assets replaced by asset type for each of the years 2013 to 2018

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-64.

b) Please see Table 2 below for Secondary Networks Work Requests
Table 2: 2013 – 2018 Work Requests (Secondary Network)

<table>
<thead>
<tr>
<th>Number of work requests</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Network</td>
<td>59</td>
<td>118</td>
<td>186</td>
<td>176</td>
<td>253</td>
<td>306</td>
</tr>
</tbody>
</table>

3) Please see Table 3 below for major Underground Asset replaced.

Table 3: Major Underground Assets replaced

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable Chamber</td>
<td>14</td>
<td>26</td>
<td>28</td>
<td>21</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Network Protector</td>
<td>5</td>
<td>14</td>
<td>13</td>
<td>27</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Switch</td>
<td>72</td>
<td>52</td>
<td>112</td>
<td>85</td>
<td>109</td>
<td>45</td>
</tr>
<tr>
<td>Underground Transformer</td>
<td>260</td>
<td>382</td>
<td>356</td>
<td>601</td>
<td>530</td>
<td>454</td>
</tr>
<tr>
<td>Transformer Pad</td>
<td>8</td>
<td>13</td>
<td>11</td>
<td>26</td>
<td>53</td>
<td>18</td>
</tr>
<tr>
<td>Vault Asset</td>
<td>46</td>
<td>158</td>
<td>157</td>
<td>210</td>
<td>426</td>
<td>368</td>
</tr>
</tbody>
</table>

4) Please see Table 4 below for major Overhead Assets replaced.

Table 4: Major Overhead Assets replaced

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Transformer</td>
<td>181</td>
<td>188</td>
<td>215</td>
<td>107</td>
<td>109</td>
<td>45</td>
</tr>
<tr>
<td>Switch</td>
<td>45</td>
<td>63</td>
<td>62</td>
<td>40</td>
<td>56</td>
<td>33</td>
</tr>
<tr>
<td>Pole</td>
<td>219</td>
<td>347</td>
<td>336</td>
<td>192</td>
<td>225</td>
<td>125</td>
</tr>
</tbody>
</table>
e) Please see Table 5 below for major Station Assets replaced.

Table 5: Major Station Assets replaced

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Battery</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>24</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Station Power Transformer</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Switches</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Station Air Compressor</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Station Switchgear</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 63:
Reference(s): Exhibit 2B, Section E6.7, p. 11, Figure 5

49% of sustained feeder outages are caused by Defective Equipment.

Please provide a breakdown of the contribution to Defective Equipment by equipment type.

RESPONSE:
Please refer to Table 1 below for the breakdown of Feeder Outages by equipment type:

Table 1: Feeder Outages by Defective Equipment Type

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Distribution of Outages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Transformers</td>
<td>9.5%</td>
</tr>
<tr>
<td>Overhead Switches</td>
<td>7.3%</td>
</tr>
<tr>
<td>Poles and Pole Hardware</td>
<td>10.6%</td>
</tr>
<tr>
<td>Other Overhead Equipment</td>
<td>14.4%</td>
</tr>
<tr>
<td>Underground Cables</td>
<td>36.1%</td>
</tr>
<tr>
<td>Underground Switches</td>
<td>2.9%</td>
</tr>
<tr>
<td>Underground Transformers</td>
<td>13.2%</td>
</tr>
<tr>
<td>Other Underground Equipment</td>
<td>4.8%</td>
</tr>
<tr>
<td>Station Equipment</td>
<td>1.2%</td>
</tr>
</tbody>
</table>
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO
INTERROGATORIES

INTERROGATORY 64:

Reference(s): Exhibit 2B, Section E6.7, p. 15, Table 6

a) Please provide a breakdown of Reactive Capital spending for the years 2013 to
2018 by major asset type.

b) Please provide a breakdown of Reactive Capital spending for the years 2015 to
2018 based on overhead, underground, secondary network, stations and metering
assets.

RESPONSE:

a) Capital spending by asset class is not available.

b) System level spending is provided in Table 1 below.

Table 1: Reactive capital spending from 2015-2017 ($M)

<table>
<thead>
<tr>
<th>Reactive Capital Category¹²</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metering</td>
<td>2.0</td>
<td>2.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Overhead</td>
<td>9.6</td>
<td>11.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Station</td>
<td>0.3</td>
<td>0.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Underground</td>
<td>27.1</td>
<td>35.9</td>
<td>38.2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>39.0</strong></td>
<td><strong>50.2</strong></td>
<td><strong>52.5</strong></td>
</tr>
</tbody>
</table>

¹ Note data for 2018 is not available at the moment.
² Secondary network financials cannot be extracted separately but it is part of the underground system.

Panel: Distribution System Capital and Maintenance
RESPONSES TO ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORIES

INTERROGATORY 65:
Reference(s): Exhibit 2B, Section E6.7, p. 16, Figure 11

a) Please discuss if the forecast trends assume same levels of work volume requests for underground, overhead, secondary network and metering work.

RESPONSE:
Yes, the forecast assumes a constant level of volume throughout the 2020-2024 period. As noted in Exhibit 2B, Section 6.7, page 16, lines 12-14, Toronto Hydro forecasted work volumes based on historic trends, and more specifically, did so using a weighted average over the 2014-2017 period.

Approximately 1,700 work requests are forecasted annually with approximately two thirds coming from the underground and network systems, approximately 30 percent from the overhead system, and the remaining from the stations system.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 52:

Reference(s): Exhibit 2B, Section A1, p. 1

Please provide details of the "adjustments for typical changes and evolving circumstances" and "gradual improvements to reliability".

RESPONSE:

"Adjustments for typical changes and evolving circumstances" refers to various factors that may impact the subsequent execution of the DSP. These include execution considerations such as weather, third-party coordination, easements, and emerging risks that may impact the expenditure plan and execution timing. More details regarding execution considerations are provided as part of the Program Management and Execution section in Exhibit 2B, Section D1.2.3, page 19. A discussion of Toronto Hydro’s historical reliability performance is provided in Exhibit 2B, Section E2.2.2.3.
INTERROGATORY 53:

Reference(s): Exhibit 2B, Section A3, p. 8

What are the other allocations noted in Footnote 2?

RESPONSE:

Other allocations refers to Inflation, Allowance for Funds Used During Construction and Engineering and Admin Reclassification.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 54:
Reference(s): Exhibit 2B, Section A4, p. 9, Figure 2

Why does the system renewal budget escalate from 2020 to 2021 and again from 2021 to 2022? Please explain.

RESPONSE:

Exhibit 2B, Section E4.2, starting on page nine, provides a summary explanation of the capital expenditures proposed over the 2020-2024 period in the system renewal investment category. Additional information can also be found in the System Renewal programs at Exhibit 2B, Section E6.

As a point of clarification, Toronto Hydro notes that from 2021 to 2022 there is actually a slight decrease of $2.6 million in the expenditure plan for the system renewal category.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 55:
Reference(s): Exhibit 2B, Section A4, p. 10

Please compare APUL and asset condition data and explain why an increase in APUL would only likely result in a corresponding determination of reliability (our emphasis).

RESPONSE:
The Assets Past Useful Life ("APUL") measure provides an aggregate, system-wide indication of the age demographics of Toronto Hydro's distribution assets. As assets age, they become more likely to fail, and these failures can result in customer interruptions. Therefore, an increase in the APUL backlog indicates an increase in the likelihood of system-wide asset failures that can result in customer interruptions and other negative outcomes.

Asset condition data is also an indicator of the likelihood of asset failure. As an asset's condition deteriorates, it becomes more likely to fail. Therefore, similar to the APUL measure, an increase in the number of assets exhibiting deterioration indicates an increase in the likelihood of asset failures that can result in customer interruptions and other negative outcomes.
INTERROGATORIES

INTERROGATORY 56:

Reference(s): Exhibit 2B, Section A4, p. 15

Please identify by area, the number of new buildings constructed (Figure 5).

RESPONSE:

Figure 5 is taken from the Toronto Economic Bulletin, September 8, 2017, attached as Appendix A to this response. The bulletin does not include the number of new buildings constructed by area. Page 7 of this bulletin identifies a subset of the tallest buildings under construction in Toronto and their addresses.
The Toronto Economic Bulletin provides a monthly snapshot of the city/regional economy. It contains labour market information and data on GDP estimates, real estate activity, retail sales, transportation and city rankings. For more information on the city and regional economies, as well as more detailed data, please see the City of Toronto’s Economic Data Centre, which also provides links to other data sources about the city. For historical time series of Economic Bulletin data, please see: Open Data.

### Snapshot

<table>
<thead>
<tr>
<th>Geography</th>
<th>Most Recent Period</th>
<th>Previous Period</th>
<th>Same Period Last Year</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2017 (3 Month Average SA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>7.0%</td>
<td>7.2%</td>
<td>7.1%</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>6.3%</td>
<td>6.5%</td>
<td>6.9%</td>
<td></td>
</tr>
<tr>
<td>Participation Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2017 (3 Month Average SA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>64.1%</td>
<td>64.4%</td>
<td>63.8%</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>65.8%</td>
<td>65.8%</td>
<td>65.5%</td>
<td></td>
</tr>
<tr>
<td>Total Employment (000s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2017 (3 Month Average SA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>1,478</td>
<td>1,480</td>
<td>1,448</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>18,426</td>
<td>18,400</td>
<td>18,055</td>
<td></td>
</tr>
<tr>
<td>Building Permits Issued (millions $)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 2017 (3 Month Average)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>$920</td>
<td>$986</td>
<td>$442</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>$9,857</td>
<td>$9,153</td>
<td>$7,976</td>
<td></td>
</tr>
<tr>
<td>Tall Buildings Under Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2017 (skyscraperpage.com)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>138</td>
<td>137</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>Office Vacancy Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>5.2%</td>
<td>5.2%</td>
<td>5.7%</td>
<td></td>
</tr>
<tr>
<td>Business Bankruptcies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>11</td>
<td>19</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>226</td>
<td>284</td>
<td>261</td>
<td></td>
</tr>
<tr>
<td>Employment Insurance Recipients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2017 (3 Month Average)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>18,560</td>
<td>21,387</td>
<td>20,377</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>424,157</td>
<td>515,133</td>
<td>450,123</td>
<td></td>
</tr>
<tr>
<td>Consumer Price Index</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>July 2017 (Annual Change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto CMA</td>
<td>2.0%</td>
<td>2.1%</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1.2%</td>
<td>1.0%</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>Retail Sales (billions $)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2017 (3 Month Average SA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto CMA</td>
<td>$7.35</td>
<td>$7.39</td>
<td>$6.80</td>
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</tr>
<tr>
<td>Canada</td>
<td>$48.87</td>
<td>$48.64</td>
<td>$45.56</td>
<td></td>
</tr>
</tbody>
</table>

Note: Top symbol compares how Toronto’s position has changed; bottom symbol compares Toronto’s performance to Canada.
The Labour Force Survey data on pages 2 & 3 of this publication are seasonally adjusted monthly data; therefore, they are not identical to the LFS data in the Snapshot section on page 1. The Snapshot data are presented as three month averages, because LFS results for a single month are often volatile.

### Employment Rate

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>59.6%</td>
<td>59.6%</td>
<td>59.5%</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>905</td>
<td>63.9%</td>
<td>63.2%</td>
<td>63.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>61.0%</td>
<td>60.8%</td>
<td>60.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>61.6%</td>
<td>61.6%</td>
<td>61.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The seasonally adjusted monthly employment rate (total employed divided by population age 15+) for city of Toronto residents was unchanged in August 2017. It is now back to where it was a year ago, before it bounced up to 60.8% in January 2017.

### Unemployment Rate

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>6.9%</td>
<td>6.9%</td>
<td>8.0%</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>905</td>
<td>4.5%</td>
<td>6.9%</td>
<td>6.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>5.7%</td>
<td>6.1%</td>
<td>6.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>6.2%</td>
<td>6.3%</td>
<td>7.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The seasonally adjusted monthly unemployment rate for city residents was unchanged in August. It remains below where it was in 2008 (7.6%), and well below its long-run (30 year) average (8.4%).

At the same time, the unemployment rate for 905 residents fell to a level not seen since Jan 2001.

NB: the LFS monthly results for the Vancouver and Montreal CMAs also showed a great deal of volatility in August.

### Participation Rate

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>64.0%</td>
<td>64.0%</td>
<td>64.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>905</td>
<td>66.9%</td>
<td>67.8%</td>
<td>67.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>64.6%</td>
<td>64.8%</td>
<td>64.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>65.7%</td>
<td>65.7%</td>
<td>65.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The seasonally adjusted monthly labour force participation rate for city residents was unchanged in August 2017. It remains 1.5% lower than it was in January 2017, and 2.1% lower than it was in 2008 (66.1%).

*Except on page 1, chart symbols refer to direction only, not to the levels of the indicators

*City of Toronto population rebased and seasonal adjustments by City staff
The Labour Force Survey data on pages 2 & 3 of this publication are seasonally adjusted monthly data; therefore, they are not identical to the LFS data in the Snapshot section on page 1. The Snapshot data are presented as three month averages, because LFS results for a single month are often volatile.

### Employment (000s)

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>1,479.3</td>
<td>1,477.2</td>
<td>1,454.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>905</td>
<td>1,808.7</td>
<td>1,782.1</td>
<td>1,745.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>7,137.4</td>
<td>7,106.3</td>
<td>6,983.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>18,444.1</td>
<td>18,421.9</td>
<td>18,069.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number of employed city of Toronto residents increased by 2,100 in August 2017 on a seasonally adjusted basis.

The total number of employed city residents now stands 24,700 higher than it was a year ago and 135,400 higher than it was in 2008.

### Unemployment (000s)

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>108.9</td>
<td>109.8</td>
<td>126.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>905</td>
<td>85.7</td>
<td>131.3</td>
<td>122.5</td>
<td></td>
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<tr>
<td>Ontario</td>
<td>428.3</td>
<td>465.1</td>
<td>502.2</td>
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<tr>
<td>Canada</td>
<td>1,226.6</td>
<td>1,246.8</td>
<td>1,363.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number of unemployed city of Toronto residents decreased by 900 in August 2017. At the same time, the number of 905 residents that are unemployed fell to a level not seen since 2007.

NB: the LFS monthly results for the Vancouver and Montreal CMAs also showed a great deal of volatility in August.

### Not In Labour Force (000s)

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>893.5</td>
<td>892.0</td>
<td>865.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>905</td>
<td>936.0</td>
<td>908.0</td>
<td>895.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>4,144.1</td>
<td>4,118.7</td>
<td>4,060.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>10,284.6</td>
<td>10,250.5</td>
<td>10,205.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In August 2017, the total number of city of Toronto residents age 15+ that are neither employed nor looking for work increased by 1,500, on a seasonally adjusted monthly basis, as more people decided not to look for work.

*City of Toronto population rebased and seasonal adjustments by City staff*
Mean Hourly Wage

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>$26.94</td>
<td>$26.61</td>
<td>$26.58</td>
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</tr>
<tr>
<td>CMA</td>
<td>$26.62</td>
<td>$26.53</td>
<td>$26.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>$26.13</td>
<td>$26.05</td>
<td>$25.88</td>
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</tr>
<tr>
<td>Canada</td>
<td>$25.93</td>
<td>$25.79</td>
<td>$25.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On a month-over-month basis, the mean (average) wage rate for city residents increased by $0.33 in August 2017.

Median Hourly Wage

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>$21.98</td>
<td>$22.00</td>
<td>$21.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMA</td>
<td>$22.00</td>
<td>$22.00</td>
<td>$21.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>$22.00</td>
<td>$22.00</td>
<td>$21.63</td>
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<td>Canada</td>
<td>$22.00</td>
<td>$22.00</td>
<td>$21.98</td>
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</table>

The median hourly wage for city residents decreased slightly in August 2017.

Percent Self Employed

<table>
<thead>
<tr>
<th></th>
<th>Aug-17</th>
<th>Jul-17</th>
<th>Aug-16</th>
<th>MoM</th>
<th>YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>17.6%</td>
<td>16.5%</td>
<td>15.5%</td>
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<td></td>
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<tr>
<td>CMA</td>
<td>17.4%</td>
<td>16.8%</td>
<td>15.9%</td>
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<tr>
<td>Ontario</td>
<td>15.5%</td>
<td>15.4%</td>
<td>15.3%</td>
<td></td>
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</tr>
<tr>
<td>Canada</td>
<td>15.3%</td>
<td>15.1%</td>
<td>15.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The percentage of employed city residents that are self-employed increased in August 2017 to 17.6%, from 16.5% in July.

The percent self-employed set a 30+ year record in April 2017 (18.9%). Comparable data go back to 1987, when 10.3% of employed city residents were self-employed.

No directional flags provided for this series, because there is no consensus for desired direction.
As the Toronto CMA recovered from the 2008/2009 recession, the regional economy expanded at rates that were above its long-run sustainable rate of growth. The average annual growth rate has been 3.1%, for the last four years, substantially higher than population growth of about 1.6% per year. As the economy moves closer to full employment, economic growth rates are expected to moderate.

Since the beginning of this year, both Oxford Economics (+0.34%) and the Conference Board of Canada (+0.32%) have revised their growth forecasts upwards for the next three years. At the same time, Moody’s has substantially downgraded their three year Toronto CMA forecast (-1.67%).

Sources: Conference Board of Canada (September 8), Moody's Analytics (August 30), Oxford Economics (July 4)
According to Skyscraperpage.com, there were 138 high-rise and mid-rise buildings under construction in the city of Toronto on September 6, 2017, which is one more than a year ago (137). Emporis, another data source, indicates that the number of tall buildings under construction in Toronto has increased from 123 a year ago to 173 buildings today. Both sources confirm that Toronto is in second place after New York City, or tied for first place in North America, by the number of major buildings under construction. Toronto currently has four buildings greater than 60 stories under construction and eleven buildings greater than 70 stories proposed for construction, according to Skyscraperpage.com.
<table>
<thead>
<tr>
<th>Building</th>
<th>Address</th>
<th>Metres</th>
<th>Feet</th>
<th>Floors</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eau de Soleil Sky Tower</td>
<td>2183 Lakeshore Blvd. W</td>
<td>228.2</td>
<td>749</td>
<td>66</td>
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</tr>
<tr>
<td>Ten York</td>
<td>10 York St</td>
<td>224</td>
<td>735</td>
<td>65</td>
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<td>Massey Tower</td>
<td>197 Yonge St</td>
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<td>The Residences of 488 University Avenue</td>
<td>488 University Ave</td>
<td>207</td>
<td>679</td>
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<td>YC Condos</td>
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<td>198.5</td>
<td>651</td>
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<tr>
<td>E Condos South</td>
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<td>642</td>
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<td>Wellesley on the Park</td>
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<td>637</td>
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<td>22/21 Yonge</td>
<td>2221 Yonge St</td>
<td>192.5</td>
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<td>One Yorkville</td>
<td>1 Yorkville Ave</td>
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<td>Lighthouse Tower Condominium</td>
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<td>Eau de Soleil Water Tower</td>
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<td>CASA III</td>
<td>50 Charles St E</td>
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<td>589</td>
<td>55</td>
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<td>Teahouse Condominiums South</td>
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<td>571</td>
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<td>592 Sherbourne St</td>
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<td>Grid Condos</td>
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<td>157</td>
<td>515</td>
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<td>Dundas Square Gardens</td>
<td>251 Jarvis Street</td>
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<td>512</td>
<td>48</td>
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<tr>
<td>The PJ Condos</td>
<td>283 Adelaide Street West</td>
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<td>511</td>
<td>50</td>
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<tr>
<td>King Blue by Greenland North Tower</td>
<td>355 King St W</td>
<td>155.8</td>
<td>511</td>
<td>48</td>
<td>2018</td>
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<tr>
<td>87 Peter</td>
<td>87 Peter St</td>
<td>154</td>
<td>505</td>
<td>49</td>
<td>2017</td>
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<tr>
<td>Monde</td>
<td>12 Bonnymastle St</td>
<td>150</td>
<td>492</td>
<td>44</td>
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<td>Westlake Encore</td>
<td>Westlake Encore</td>
<td>146.5</td>
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<td>45</td>
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<tr>
<td>Islington Terrace</td>
<td>Cordova Avenue &amp; Mabelle Avenue</td>
<td>144</td>
<td>472</td>
<td>45</td>
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<tr>
<td>King Blue by Greenland South Tower</td>
<td>King Blue by Greenland South Tower</td>
<td>140.4</td>
<td>461</td>
<td>44</td>
<td>2018</td>
</tr>
<tr>
<td>The Britt</td>
<td>The Britt</td>
<td>139</td>
<td>456</td>
<td>41</td>
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<tr>
<td>43 Gerrard West</td>
<td>43 Gerrard West</td>
<td>138.6</td>
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<td>43</td>
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<tr>
<td>150 Redpath</td>
<td>150 Redpath Ave</td>
<td>132.3</td>
<td>434</td>
<td>38</td>
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<td>Cumberland at Yorkville Plaza</td>
<td>Cumberland at Yorkville Plaza</td>
<td>124.8</td>
<td>409</td>
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<tr>
<td>E Condos North</td>
<td>E Condos North</td>
<td>122.8</td>
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<td>155 Redpath</td>
<td>155 Redpath Ave</td>
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<td>395</td>
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<tr>
<td>159SW Tower</td>
<td>159 Wellesley Street East</td>
<td>118.9</td>
<td>390</td>
<td>36</td>
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<td>City Lights on Broadway I</td>
<td>99 Broadway Ave</td>
<td>116</td>
<td>381</td>
<td>34</td>
<td>2018</td>
</tr>
<tr>
<td>Bloorvista</td>
<td>Cordova Avenue &amp; Mabelle Avenue</td>
<td>114</td>
<td>374</td>
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<tr>
<td>101 Erskine</td>
<td>101 Erskine Ave</td>
<td>106.4</td>
<td>349</td>
<td>32</td>
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<tr>
<td>River City 3</td>
<td>210 Eastern Avenue</td>
<td>99.7</td>
<td>327</td>
<td>29</td>
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<tr>
<td>Cypress at Pinnacle Etobicoke</td>
<td>5475 Dundas St W</td>
<td>83.8</td>
<td>275</td>
<td>25</td>
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<td>Smart House</td>
<td>227 Queen St W</td>
<td>83.6</td>
<td>274</td>
<td>25</td>
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<td>Park Towers East, Phase 2 at IQ</td>
<td>400 Walmer Rd</td>
<td>77.2</td>
<td>253</td>
<td>24</td>
<td>2018</td>
</tr>
<tr>
<td>Park Towers West, Phase 2 at IQ</td>
<td>400 Walmer Rd</td>
<td>77.2</td>
<td>253</td>
<td>24</td>
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<tr>
<td>Rise</td>
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<td>75.3</td>
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<td>75</td>
<td>246</td>
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<td>Axiom East Tower</td>
<td>424 Adelaide St E</td>
<td>69</td>
<td>226</td>
<td>19</td>
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<td>King HighLine</td>
<td>1100 King St W</td>
<td>57.6</td>
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<td>Omega on the Park</td>
<td>115 McMahon Drive</td>
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<td>One The Kip District</td>
<td>5365 Dundas St W</td>
<td>-</td>
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<td>28</td>
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<tr>
<td>St. Michael's Hospital Patient Care Tower &amp; Em Queen and Victoria St</td>
<td>-</td>
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<td>17</td>
<td>2017</td>
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<tr>
<td>2150 Condos West</td>
<td>1320 Birchmount Rd</td>
<td>-</td>
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<td>Canary Park Condominiums</td>
<td>398 Front St E</td>
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<td>Cove at Waterways</td>
<td>2169 Lake Shore Blvd W</td>
<td>-</td>
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<td>2017</td>
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<tr>
<td>West Village 4</td>
<td>2 - 6 Eva Rd</td>
<td>-</td>
<td>-</td>
<td>16</td>
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</tr>
</tbody>
</table>

Source: Council on Tall Buildings and Urban Habitat (September 6, 2017)

Tallest buildings under construction in Toronto
Toronto’s office market continues to exhibit a lot of strength, as vacancy rates in the city remain unchanged in 2017q2 at 5.2%; the lowest level since 2008q3. In “905” municipalities vacancy rates decreased (by 0.4%) from the previous quarter to 12.3% in 2017q2. Toronto’s downtown core is very attractive for office space users (vacancy rate 3.6% in 2017q2), and office vacancy rates in the rest of the city are also lower than the “905” average.

Strong demand downtown recently led Cadillac Fairview to announce that it was proceeding with 16 York St “on spec” (i.e. without signing a lead tenant). 16 York St will add 879,000 sq ft to office space under construction, bringing the total under construction downtown to over 4.4 million sq ft.

Economic Development & Culture - www.toronto.ca/ecdevdata - September 8, 2017
The city of Toronto contains almost 250 million square feet of industrial space, which is more than any other GTA municipality and is a third of the regional total. Between 2017q1 and 2017q2, the industrial vacancy rate in the city of Toronto declined from 2.3% to 1.9%. This is the lowest industrial vacancy rate in the city of Toronto in the last 18 years. At the same time, however, total occupied space also declined, because the supply of industrial space in the city of Toronto decreased by 3,254,361 sq. ft. in 2017q2.
When comparing 2017q2 with the same period last year, housing starts in the city of Toronto fell by 43%. Quarterly housing starts are also 19% lower than the ten year average (4,171). Toronto’s share of regional housing starts was 40% in 2017q2. Since 2008, city of Toronto housing starts have accounted, on average, for 47% of total starts in the Toronto CMA. High-rise buildings continue to dominate new residential construction starts in Toronto, accounting for 84% of total starts in 2017q2.
The City of Toronto issued more than $750 million worth of building permits in July 2017, down 37.9% from June and a decrease of 6.7% from the same month in 2016.

At the same time, "905" permit values increased by 13.8% on a monthly basis in July 2017 and are up by 15.8% compared to a year ago.

The City issued $387 million worth of building permits for non-residential structures (ICI) in July, and this accounted for 34.4% of value of all non-residential permits in the Toronto CMA, in comparison to the city’s share of 56.5% in July 2016.

ICI permit values in the "905" doubled in July 2017 from June, whereas they decreased in the city by 41% during the same time frame.

Lower construction intentions for industrial (-89.1%) and institutional (-70.5%) were mainly responsible for the decline of building permit values in Toronto in July. Commercial permits are down slightly (-0.07%) on a month-to-month basis.

In the first half of 2017, permits were issued for several large institutional projects in Toronto. These include $245 million for additions/alterations to Mount Sinai Hospital and $131 million for four separate University of Toronto additions/alterations.
In June 2017, about one-third of total retail sales generated from Canada’s three largest census metropolitan areas (CMAs): Toronto, Vancouver and Montreal. Seasonally adjusted retail sales in the Toronto CMA were down in June (-2.4%) compared to May and stood at $7.22 billion. Total retail sales in Toronto CMA in June are as large as the combined sales from both Vancouver and Montreal.

Note: Historically, Statistics Canada did not seasonally adjust retail sales data for CMA’s and City staff did our own seasonal adjustments. Starting in June 2017, however, Statistics Canada is publishing seasonally adjusting total retail sales for the Toronto CMA; therefore, starting with this issue of the Economic Bulletin, we are reporting Statistics Canada’s retail sales seasonal adjustments.
In June 2017, the number of business bankruptcies in the city of Toronto declined by 42.1% from the previous month; however, the business bankruptcy data are very volatile on a monthly basis. There is a downward trend evident in the data in the last two years.

Consumer bankruptcies in the city declined by 11% and stood at 243 in June 2017 from May. Similar to business bankruptcy data, these data are also fairly volatile on a monthly basis, and there is a downward trend evident in the last two years.

Bank of Canada target inflation rate is between 1-3%.
On a monthly basis, average weekday ridership in July 2017 was lower than in June 2017.

TTC ridership exhibits strong seasonality, so one cannot merely look at the month-month changes.

The moving annual total is down slightly on a monthly basis and remains in line with the 24 month average (536 million).

Average weekday GO Transit ridership increased by 2.3% on a monthly basis in June 2017 and increased by 3.8% when compared to the same period of time last year.

Total GO Transit passengers also increased in June 2017; however, the total passenger figure is affected not only by seasonal factors, but also by the number of working days in each month, which varies from year to year.

Total passengers going through Toronto Pearson Airport increased by 7.5% in June on a monthly basis.

Compared to a year ago, total passengers increased by 6.6% in June 2017.
Toronto is one of the most livable and competitive cities in the world as demonstrated by various international rankings and reports. In addition to securing its position on the world stage, Toronto’s rankings confirm that it continues to offer a high quality of life for 2.9 million residents who choose to live and work here.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Year</th>
<th>Source</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2015</td>
<td>The Economist – Best Place to Live</td>
<td>Global - 50 cities</td>
</tr>
<tr>
<td>1</td>
<td>2015</td>
<td>Metropolis – The World’s Most Livable Cities</td>
<td>Global - 10 cities</td>
</tr>
<tr>
<td>1</td>
<td>2015</td>
<td>PWC - Building Better Cities</td>
<td>Global - 28 cities</td>
</tr>
<tr>
<td>1</td>
<td>2016</td>
<td>KPMG’s Comparative Alternatives Study – Focus on Tax</td>
<td>Global - 111 cities</td>
</tr>
<tr>
<td>2</td>
<td>2016</td>
<td>Christie’s – Global Luxury Real Estate White Paper</td>
<td>Global - 80 cities</td>
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<tr>
<td>3</td>
<td>2016</td>
<td>PricewaterhouseCoopers - Cities of Opportunity 7</td>
<td>Global - 30 cities</td>
</tr>
<tr>
<td>3</td>
<td>2016</td>
<td>Expert Market: World’s Best Tech Hubs - To Work &amp; Live</td>
<td>Global - 10 cities</td>
</tr>
<tr>
<td>4</td>
<td>2016</td>
<td>National Taiwan University - Scientific Papers for Uni.</td>
<td>Global - 500 cities</td>
</tr>
<tr>
<td>4</td>
<td>2016</td>
<td>KPMG’s Comparative Alternatives Study – Business Costs</td>
<td>Global - 29 cities</td>
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<tr>
<td>4</td>
<td>2017</td>
<td>The Economist Intelligence Unit – Liveability Ranking</td>
<td>Global - 140 cities</td>
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<td>4</td>
<td>2016</td>
<td>Transit Score - Public Transit Coverage</td>
<td>NA - 130 cities</td>
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<tr>
<td>4</td>
<td>2017</td>
<td>Global Fintech Centres of the Future</td>
<td>Global - 13 cities</td>
</tr>
<tr>
<td>5</td>
<td>2015</td>
<td>Toronto Region Board of Trade – Scorecard on Prosperity</td>
<td>Global - 24 metros</td>
</tr>
<tr>
<td>6</td>
<td>2015</td>
<td>fDI Magazine – American Cities of the Future</td>
<td>NA - 10 cities</td>
</tr>
<tr>
<td>6</td>
<td>2016</td>
<td>Youthful Cities – The World’s Most Youthful Cities</td>
<td>Global - 55 cities</td>
</tr>
<tr>
<td>8</td>
<td>2015</td>
<td>The Economist – The Safe Cities Index</td>
<td>Global - 50 cities</td>
</tr>
<tr>
<td>8</td>
<td>2014</td>
<td>Boston Consulting Group – Destinations for Job-Seekers</td>
<td>Global - 25 cities</td>
</tr>
<tr>
<td>9</td>
<td>2015</td>
<td>QS Best Student Cities – University Ranking</td>
<td>Global - 9 cities</td>
</tr>
<tr>
<td>10</td>
<td>2017</td>
<td>Z/Yen Group – Global Financial Centres Index 21</td>
<td>Global - 106 cities</td>
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<tr>
<td>10</td>
<td>2017</td>
<td>Resonance Consultancy - World’s Best City Brands Report</td>
<td>Global - Top 100 cities</td>
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<td>12</td>
<td>2015</td>
<td>Arcadis – Sustainable Cities Index – 2015</td>
<td>Global - 50 cities</td>
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<td>16</td>
<td>2017</td>
<td>Mercer Consulting– Quality of Living Ranking Survey</td>
<td>Global - 450 cities</td>
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<tr>
<td>27</td>
<td>2016</td>
<td>Shanghai Jiao Tong University – University Rankings</td>
<td>Global - 1000 uni.</td>
</tr>
<tr>
<td>30</td>
<td>2016</td>
<td>Centre for World University Rankings - University Rankings</td>
<td>Global - 1000 uni.</td>
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RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 57:

Reference(s): Exhibit 2B, Section A4, p. 16

a) Please provide the number of micro-turbine installations in: (a) municipal; (b) commercial customers; in THESL’s franchise.

b) How many (a) residential; (b) small C&I meter seals expired or are forecast to expire each year between 2018 and 2024, inclusive. Will all of the replacement meters (i) report failures; (ii) accelerate restoration of service, communicate data to THESL and third parties, if requested and approved? If some will not do these functions, why not?

RESPONSE:

a) Please see Table 1 below.

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<thead>
<tr>
<th>Type</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>Total</th>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>Commercial</td>
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<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
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Panel: Distribution System Capital and Maintenance
b) Please see Table 2 below for the number of residential and small C&I meter seals that are expired or are forecast to expire each year between 2018 and 2024.

<table>
<thead>
<tr>
<th>Type</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
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<td>Residential</td>
<td>129,409</td>
<td>29,590</td>
<td>16,952</td>
<td>7,820</td>
<td>2,546</td>
<td>9,839</td>
<td>202,577</td>
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<td>Small C&amp;I</td>
<td>11,388</td>
<td>13,610</td>
<td>17,890</td>
<td>6,669</td>
<td>2,011</td>
<td>1,022</td>
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</tbody>
</table>

All new Residential and small Commercial and Industrial meters will support “last gasp” functionality, allowing an alert to be communicated when meters experience an interruption. This data will be communicated to Toronto Hydro (not to any third party) for restoration efforts and crew dispatch, and used to accelerate service restoration by enabling crews to locate and address the source of an outage in a more timely manner, thus resulting in a corresponding effect on system-wide SAIDI. For more information, please refer to Exhibit 2B, Section E5.4.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 58:
Reference(s): Exhibit 2B, Section A4, pp. 22-23

What are the expected manpower-related dollar savings in each year of the plan from the implementation of the capex on remote monitoring, sensing, protection, and control?
What are the savings from each of standardization, removal of leaking transformers (remediation and penalty costs), enhanced work coordination, procurement measures?
Please discuss fully.

RESPONSE:
Please refer to Toronto Hydro's response to interrogatory 2B-Staff-62.
INTERROGATORY 59:
Reference(s): Exhibit 2B, Section A4, p. 24

What percentage of the total cost of each category of capital expenditure, including capitalized engineering project management, overheads are performed by third party services acquired through competitive procurement processes?

RESPONSE:
Please see below the estimated percentage of capital costs determined through competitive procurement processes. These costs include materials sourced from third-parties.

| Table 1: Percentage of Total Capital from Third Party Services |
|-------------------|------------------|------------------|
|                   | 2015             | 2016             | 2017             |
|                   | 84.5%            | 82.2%            | 87.5%            |
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 60:
Reference(s): Exhibit 2B, Section A4, p. 32

Please provide a copy of the review and update of Reliability Centered Maintenance analyses (2017).

RESPONSE:
A sample of the 16 resulting compliance documents provided by METSCO following the review and update is attached as Appendix A (“SAE Compliance Letter re Overhead Gang-Operated Switches”).
30 October 2017

Mr. Chris Scarpelli
Toronto Hydro-Electric System Limited
500 Commissioners Street
Toronto, Ontario M4M 3N7

Greetings Chris,

Standard SAE JA-1011 (Evaluation Criteria for Reliability Centered Maintenance (RCM) Processes) outlines requirements for an RCM analysis process. RCM is a specific process used to identify the policies which must be implemented to manage the failure modes which could cause the functional failure of any physical asset in a given operating context. The standard is intended to be used to evaluate any process that purports to be an RCM process, in order to determine whether it is a true RCM process. The standard specifies the minimum characteristics that a process must have in order to be an RCM process. Note that it is the process used, not the individual analyses to which the standard applies.

I with assistance of engineers from METSCO Energy Solutions Inc. (MESTCO) have reviewed the method being used by Toronto Hydro-Electric Systems Limited (Toronto Hydro) to determine its failure management policies for the Asset class Overhead Gang-Operated Switch. It is my opinion that it meets the requirements of Standard SAE JA-1011.

SAE JA-1012 (“A Guide to the Reliability-Centered Maintenance (RCM) Standard”) amplifies and clarifies each of the key criteria listed in SAE JA-1011 (“Evaluation Criteria for RCM Processes”), and summarizes additional issues that must be addressed in order to apply RCM successfully. It does not provide an additional list of requirements (i.e.: shall statements) that must be met, rather it provides guidance on how to meet the requirements of SAE JA-1011. The resultant analysis produces failure management policies forming part of the maintenance program that are deemed to be the most cost and risk effective at sustaining asset performance in accordance with the company’s risk tolerance level. Meeting it can only be determined through review of actual analyses that are completed to ascertain how closely they follow that guidance.

I have worked with a team of engineers from METSCO reviewing RCM analyses performed by Toronto Hydro on the Asset Class Overhead Gang-Operated Switch. The review dates and comments of each of the reviews is included at Appendix A.

It is my opinion that the final revised analyses from that process, do indeed follow the guidance provided in SAE JA-1012.

It is my recommendation that the analysis results shall be embedded in the maintenance practices and regular RCM reviews initiated as needed when new data and/or maintenance practices become available.

Yours truly,

James V Reyes-Picknell, BASc, PEng,
CMC, CMRP, MMP, CAMA
Conscious Group Inc.
Appendix A

Asset Class – Overhead Gang-Operated Switch

Review process

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Review Stage</th>
<th>Key Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jul-2016</td>
<td>Original Analysis Submitted (RCM Worksheet) by Toronto Hydro</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12-Sep-2016</td>
<td>Comments provided on the original analysis by Conscious Asset</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>19-Jun-2017</td>
<td>Comments addressed (RCM Worksheet) and Economic Analysis provided by Toronto Hydro</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>11-Jul-2017</td>
<td>Further comments provided by Conscious Asset / METSCO</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>19-Jul-2017</td>
<td>Comments addressed by Toronto Hydro</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>24-Jul-2017</td>
<td>RCM Analysis for the asset was deemed compliant by Conscious Asset / METSOC</td>
<td></td>
</tr>
</tbody>
</table>

James V Reyes-Picknell, BASc, PEng, CMC, CMRP, MMP, CAMA
Conscious Group Inc.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 61:

Reference(s): Exhibit 2B, Section A4, p. 32

Please provide a description of the CNAIM asset health approach, and show how it differs from THESL's current approach.

RESPONSE:

A description of the CNAIM asset health approach can be found at the following location: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_in
dices_methodology_v1.1.pdf

Please refer to Exhibit 2B, Section D, Appendix C, at pages 6-8 for a discussion of how the CNAIM approach differs from Toronto Hydro's current asset condition assessment methodology.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 62:
Reference(s): Exhibit 2B, Section A4, p. 33, Table 7

a) Table 7 shows an approximate $84M (twenty percent (20%)) increase in total capex in 2020 over 2019. What is the justification for this very large increase?

b) Please provide an overall rank order of each of the individual capital projects for 2020, as well as a rank order of the projects within each of the four (4) categories for 2020.

c) Please provide the same rank ordering for each of 2021, 2022, 2023, and 2024.

d) When there are several projects within a program, provide a rank ordering of those projects within each of the twenty (20) programs.

RESPONSE:

a) As the Distribution System Plan is a five-year plan, the appropriate comparison for the capital expenditure plan is between the total 2020-2024 amounts and the total 2015-2019 actual and bridge year amounts. On this basis, Toronto Hydro is proposing to increase overall capital expenditures by approximately 19 percent. The drivers of this proposed increase are summarized in Exhibit 2B, Section E4.2 and throughout the investment programs in Exhibit 2B, Sections E5 to E8. Section E2 provides a detailed description of the capital planning process that led to these proposals, the objectives
of the plan, and alignment of the plan with customers' needs, priorities, and preferences.

b) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b).

c) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b).

d) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b).
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 63:
Reference(s): Exhibit 2B, Section A6

a) Please explain how monitoring and control technology will prevent vault fires. Please provide a detailed explanation.

b) Please provide details on how much of the current network employs SCADA technology; how much more will be covered by the proposed program (Network Condition, Monitoring, and Control). Please provide the total number of primary feeders in the THESL system, and how many are equipped with SCADA. Please detail the consequences and advantages for customers of the use of SCADA.

RESPONSE:

a) Further to the details provided in Exhibit 2B, Section E7.3.3.1, Network Condition Monitoring and Control ("NCMC") technology can prevent vault fires by identifying developing problems before they occur. The technology accomplishes this by doing the following:

i) Identifying network transformers with high gas pressure, which may result from the breakdown of oil and winding insulation, and which may indicate a developing winding failure;

ii) Identifying network transformers with low oil levels, which can result in winding insulation failure;
iii) Identifying network transformers with high top-oil temperatures, which may indicate a developing winding failure;

iv) Identifying network units with electrical loads above equipment rating, where equipment overloads can result in equipment failure; and

v) Identifying flooded network vaults, and water inside network protectors, which can result in equipment short circuits.

In addition, NCMC also monitors vault temperature, which can be indicative of a fire starting, and provide early warning to allow effective response, which minimizes damage.

b) Of the over 500 underground primary feeders in the downtown system, 268 supply network equipment. As of 2017, SCADA communication (i.e. NCMC equipment) was installed on network equipment located on 13 feeders, and as of 2018, monitoring equipment was installed on 20. The NCMC program plans to enable monitoring and control (i.e. SCADA equipment) on 90 percent of the network system by 2024. Please refer to Exhibit 2B, Section E7.3.5.3 for further information on the consequences and advantages for customers of the use of SCADA.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 64:
Reference(s): Exhibit 2B, Section B, Appendix C, p. 1

Please provide details on THESL's inspection practices for each major asset type, including:

- wood poles
- pole top transformers
- other pole top equipment
- vault transformers and pad-mounted transformers
- conductors:
  - overhead
  - underground
- station:
  - transformers
  - breaks
  - switches

RESPONSE:
Toronto Hydro's preventative and predictive maintenance practices, including inspection practices, for major asset classes are described in Exhibit 2B, Section D3.1.1, Table 1. Further information on the Preventative and Predictive Maintenance program can be found at Exhibit 4A, Tab 2, Schedules 1-3.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 65:

Reference(s): Exhibit 2B, Section E2, p. 6

a) Given the fact that THESL has a deferral account for system access expenditures, what is the practical impact, if any, of reducing the five (5) year system access capex by $65M?

b) Will THESL commit to reducing other parts of its capex, in the event the system access budget increases beyond the proposed level, in the event mandatory requirements are greater than initially forecast?

c) Please provide the projects that were deferred from the initial budget in each of the system renewal programs, in order to achieve the $325M reduction over five (5) years.

RESPONSE:

(a) Please note the correction to the referenced $65 million figure provided in response to 2B-Staff-73, part (a). The utility reduced its System Access proposals for the 2020-2024 period by approximately $80 million (as opposed to $65 million) between the initial plan and the penultimate plan. The investment category was further reduced by about $40 million between the penultimate plan and the final plan. This represents a total reduction in proposed System Access expenditures of approximately $120 million for the five year rate period. Practically, the result is a
lower amount of forecasted capital related revenue requirement for System
Access investments during the rate period. The variance account referenced in
the question has no effect on the forecasted capital related revenue requirement
included in this application.

(b) No. Toronto Hydro has provided a detailed rationale for continuing the variance
account for volatile, non-discretionary externally driven relocation work in Exhibit
2B, Section E5.2.4 and Exhibit 9, Tab 1, Schedule 1, pages 14-17. In approving this
same account in the utility’s previous Custom IR application, the OEB recognized
that these projects are completely outside of Toronto Hydro’s control as to both
need and timing, and are therefore appropriate for a variance account.¹

(c) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-73, part (a), for
information regarding changes to the System Renewal programs between the
initial and penultimate plans. For a discussion regarding the provision of project
level information for the 2020-2024 forecast period, please refer to Toronto
Hydro’s response to interrogatory 2B-SEC-36, parts (a) and (b).

¹ EB-2014-0116, Decision and Order (December 29, 2015) at page 50.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 66:

Reference(s): Exhibit 2B, Section E2, p. 7

Why did THESL increase the amount of station work on the basis that it had discovered extra capacity to complete such work? Is it overstaffed in that area?

RESPONSE:

To be clear, an increase in stations work execution capacity is not the driver of the proposed increase in Stations Renewal work, and Toronto Hydro is not overstaffed in this area. On the contrary, Toronto Hydro has historically faced resource limitations in this area.

As explained in Exhibit 2B, Section E6.6:

“[...] the proposed level of investment in the Stations Renewal program is necessary to address the backlog of high priority station assets that are at or beyond their useful life, have deteriorated in condition, and pose heightened failure risks. Given the necessity of an increased expenditure plan for Stations Renewal, Toronto Hydro has taken several steps to mitigate potential execution risks to the proposed 2020-2024 Program. These steps include increasing the use of contracted Stations design and field personnel, training and expanding the use of Toronto Hydro Stations internal resources, improved coordination with external parties and improvements in the downtown feeder outage coordination process.”
For further information on Toronto Hydro’s initiatives to mitigate Stations Renewal execution constraints experienced over the 2015-2019 period, please refer to Exhibit 2B, Section E6.6.6.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 67:
Reference(s): Exhibit 2B, Section E2, p. 7

Please provide specifics of customer support for Network Unit Renewal work in the last sentence of p7 of 58.

RESPONSE:
When asked about Toronto Hydro’s replacement of Network Units during the telephone surveys in Phase 2 of the Planning-specific Customer Engagement, 72 percent of residential customers, 62 percent of small business customers, and 75 percent of mid-market customers replied either that Toronto Hydro should stick with the proposed pace of investment or that they would be willing to pay more to replace transformers sooner. These results are tabulated in the Executive Summary of the Innovative Report filed in Exhibit 1B, Tab 3, Schedule 1, Appendix A at page 16.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 68:
Reference(s): Exhibit 2B, Section E4, p. 3

Why, despite having underspent its system access budget by sixteen percent (16%) over the 2015-2019 plan, has THESL increased its system access budget to average 100m/year in the 2020-2024 plan? How does the new plan budget take the 2015-2019 experience into account?

RESPONSE:
Toronto Hydro outlines why an increase to the System Access budget is proposed for 2020-2024 in Exhibit 2B, Section E4.2.1, page 9. Where applicable, the 2015-2019 experience has been considered in developing the forecast for 2020-2024. The factors driving this increase are discussed in each of the programs respective expenditure plan sections of the narratives (see page references below).

System Access investments have increased for the following programs:

- Customer Connections (Exhibit 2B, Section E5.1, pages 14-20);
- Externally Initiated Plant Relocations and Expansion (Exhibit 2B, Section E5.2, pages 7-16); and
- Metering (Exhibit 2B, Section E5.4, pages 13-20).
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 69:
Reference(s): Exhibit 2B, Section E4, p. 3

For 2018 and 2019, THESL has forecast shortfalls in system renewal capex relative to budget of seventeen percent (17%) and twelve percent (12%), respectively. Why has THESL then increased its system renewal budget to at least $100M per year over 2018 and 2019 forecast amounts?

Response:
As explained in Exhibit 2B, Section E4.1.1.1, there is no forecasted shortfall in the execution of Toronto Hydro's 2015-2019 System Renewal expenditure plan. In light of higher than forecast System Renewal expenditures in 2015 and 2016, Toronto Hydro reduced forecast spending in 2017, 2018 and 2019 to remain in alignment with the utility's original five-year plan for the category. Overall, Toronto Hydro is forecasting that its actual 2015-2019 System Renewal expenditures will be within one percent of the originally filed plan. As the Distribution System Plan is a five-year plan, the appropriate comparison for the System Renewal budget is between the total 2020-2024 amounts and the total 2015-2019 amounts. On this basis, Toronto Hydro is proposing to increase System Renewal expenditures by an estimated $63 million per year on average over 2015-2019 actuals and forecast. The drivers and outcomes of these investments are discussed in detail in Exhibit 2B, Section E4.2.2 and throughout the System Renewal programs in Section E6.

Panel: Distribution System Capital and Maintenance
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 70:
Reference(s): Exhibit 2B, Section E4, p. 5

Given that THESL attributes the large overrun in general plant in 2018-2019 to two (2) major projects which are now complete, why has THESL proposed an increase in general plant of approximately $50M/year over the plan term over the budgets for 2018 and 2019. Please discuss in detail.

RESPONSE:
Toronto Hydro has held overall expenditure levels in this category in line with spending comparable to the 2015-2019 period. Over the 2020-2024 period, General Plant investments are forecast to be relatively stable with expenditures averaging approximately $85 million per year, a slight increase over the 2015-2019 levels. As discussed in detail in Exhibit 2B, Section E2.2 and Section E8.1- E8.4, the moderate increase in this category is driven by the new, one-time Control Operations Reinforcement program and increases in spending for the Facilities Management and Security, Fleet and Equipment Services and IT/OT systems programs, which are generally driven by lifecycle cost management principles, business continuity needs and emerging customer needs and preferences.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 71:
Reference(s): Exhibit 2B, Section E5, p. 4

a) Please define a project for the purposes of Figure 1. What are the minimum floor
space, type of building, height, etc. that constitute a project? How many projects
make up the stated 363,859 residential units? Are single family homes and
duplexes included projects? How many forecast discrete connections to new
buildings are forecasted annually from 2020 to 2024? Does the 363,859 include
THESL’s sub-meter connections? To what extent?

b) Are updated connections to improved buildings (eg. addition of a second floor to a
bungalow) included in the unit numbers? To what extent? Please provide 2018
numbers when available.

RESPONSE:

a) Figure 1 is taken from the April 2017 “How Does the City Grow?” bulletin issued by
the City of Toronto. The bulletin does not provide project definitions or breakdowns.
As such, Toronto Hydro is unable to provide responses to any of the above questions
with respect to the details of a “project”.

Toronto Hydro has used the bulletin as a reference tool to gauge the growth trend in
the city along with the pipeline data on a yearly basis to assess the new connections
activity.
Panel: Distribution System Capital and Maintenance

1. Toronto Hydro does not have the data used for the bulletin and is therefore unable to confirm whether the 363,859 units include the utility’s sub-meter connections or the extent of the inclusion.

2. b) Please see Toronto Hydro’s response to part (a). Toronto Hydro is not able to comment on whether the updated connections to improved buildings were included in the unit numbers.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 72:
Reference(s): Exhibit 2B, Section E5, p. 7

Request to Connect appears to be declining over 2015-2017 when feeder requests are increasing, and Offer to Connect appears flat over the last five (5) years. What is the forecast load connection activity in the 2020-2024 period (extension of Figures 1 through 7, pp4-9)?

RESPONSE:
Toronto Hydro is unable to provide a forecast of load connection activity. Please refer to Exhibit 2B, Section E5.1.4.1 for a discussion of the factors that contribute to the difficulty of forecasting load connections.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 73:

Reference(s): Exhibit 2B, Section E5, p. 14

What justifies the increase in annual load connection budget from about $38M to $44M (existing vs. proposed), a difference of $30M over the new term?

RESPONSE:

As stated in Exhibit 2B, Section E5.1.4.1, page 14, the expenditure of the Customer Connections (Load Connections) segment is influenced by a variety of factors. As such, a holistic view is required to analyze and forecast expenditures. Toronto Hydro's 2020-2024 forecast is based on historical actual data (2013-2017), while accounting for inflation. Please refer to Exhibit 2B, Section E5.1.3.1 for a discussion of the growth indicators that also support Toronto Hydro's forecasted expenditures.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 74:
Reference(s): Exhibit 2B, Section E5, p. 14

Why have customer contributions as a percentage of gross connection costs declined in 2020-2024, compared to the existing plan?

RESPONSE:
Please refer to Exhibit 2B, Section E5.1, page 16, lines 2-10 and Toronto Hydro’s response to interrogatory 2B-Staff-78, part (b) for details of the utility’s 2020-2024 forecasting methodology for the Customer and Generation Connections program.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 75:
Reference(s): Exhibit 2B, Section E5, p. 14

Please provide a copy of THESL's Conditions of Service.

RESPONSE:
Toronto Hydro’s current Conditions of Service is attached as Appendix A.
CONDITIONS OF SERVICE

REVISION #18

Effective Date: January 1, 2019

Comments to these revisions can be emailed to: ConditionsofService@torontohydro.com

Customers without e-mail access can submit inquiries through regular mail to:
Standards & Technical Studies Department
Toronto Hydro-Electric System Limited
500 Commissioners Street
Toronto, Ontario
M4M 3N7

To contact Toronto Hydro call (416) 542-8000 or e-mail at: ConditionsofService@torontohydro.com
The Distribution System Code (DSC) requires that every distributor produce its own “Conditions of Service” document. The purpose of this document is to provide a means for communicating the types and level of service available to the Customers and Consumers within Toronto Hydro’s service area. The Distribution System Code requires that the Conditions of Service be readily available for review by the general public. In addition, the most recent version of the document must be provided to the Ontario Energy Board (OEB), which in turn will retain it on file for the purpose of facilitating dispute resolutions in the event that a dispute cannot be resolved between the Customer and its distributor.

The acceptance of supply of electricity or related services from Toronto Hydro constitutes the acceptance of a binding contract with Toronto Hydro which includes these Conditions of Service and all terms thereunder. The person so accepting the supply of electricity or related services shall be liable for payment for same, and such contract shall be binding upon the person's heirs, administrators, executors, successors or assigns.

This document follows the form and general content of the Condition of Service template appended to the DSC. The template was prepared to assist distributors in developing their own "Conditions of Service" document based on current practice and the DSC. The text of the template is shown in italics throughout these Conditions of Service, right after each of the subheadings. The template outlines the minimum requirements. However, as suggested by the DSC, Toronto Hydro has expanded on the contents to encompass local characteristics and other specific requirements.

Section 2 (Distribution Activities (General)) contains references to services and requirements that are common to all Customer classes. This section covers items such as Rates, Billing, Hours of Work, Emergency Response, Power Quality, Available Voltages and Metering.

Section 3 (Customer Class Specific) contains references to services and requirements specific to the respective Customer class. This section covers items such as Service Entrance Requirements, Delineation of Ownership, Special Contracts, etc.

Other sections include the Glossary of Terms, Tables and References.

Subsequent changes will be incorporated with each submission to the OEB.

A Revision Summary of the latest revisions to the Conditions of Service is posted on Toronto Hydro’s website. Comments to these revisions can be emailed to ConditionsofService@torontohydro.com. Toronto Hydro will file to the Ontario Energy Board a summary of public comments received from customers about the changes.
## TABLE OF CONTENTS

1 **INTRODUCTION**---------------------------------------------------------------6

1.1 Identification of Distributor and Service Area-----------------------------------6
   1.1.1 Distribution Overview---------------------------------------------------------6

1.2 Related Codes and Governing Laws-------------------------------------------------7

1.3 Interpretations------------------------------------------------------------------8

1.4 Amendments and Changes-----------------------------------------------------------8

1.5 Contact Information---------------------------------------------------------------8

1.6 Customer Rights-----------------------------------------------------------------9

1.7 Distributor Rights----------------------------------------------------------------9
   1.7.1 Access to Customer Property---------------------------------------------------9
   1.7.2 Safety of Equipment------------------------------------------------------------10
   1.7.3 Tree and Vegetation Management-----------------------------------------------11
   1.7.4 Operating Control-------------------------------------------------------------11
   1.7.5 Customer-Owned Equipment, Infrastructure, and Property-----------------------12

1.8 Disputes------------------------------------------------------------------------14

2 **DISTRIBUTION ACTIVITIES (GENERAL)**-------------------------------------------15

2.1 Connections - Process and Timing-----------------------------------------------15
   2.1.1 Building that Lies Along------------------------------------------------------16
       2.1.1.1 Connection Charges-------------------------------------------------------17
   2.1.2 Expansions / Offer to Connect-----------------------------------------------17
       2.1.2.1 Offer to Connect & Alternative Bid Work---------------------------------19
       2.1.2.2 Capital Contribution Policy---------------------------------------------21
       2.1.2.2.1 Offer to Connect – Content & Process---------------------------------22
       2.1.2.2.2 Transfer Price for Work that is Eligible for Alternative Bid---------23
       2.1.2.2.3 Alternative Bid Final Economic Evaluation & Capital Contribution Settlement----23
   2.1.2.3 Expansion Deposit------------------------------------------------------------24
   2.1.2.4 Supply Agreement-------------------------------------------------------------26
   2.1.2.5 Rebates of Capital Contribution---------------------------------------------26
   2.1.2.6 Feeder Capacity Optimization-----------------------------------------------27
   2.1.3 Connection Denial-------------------------------------------------------------28
   2.1.4 Inspections Before Connections-----------------------------------------------29
   2.1.5 Relocation of Plant-----------------------------------------------------------29
   2.1.6 Easements-------------------------------------------------------------------31
   2.1.7 Contracts-------------------------------------------------------------------31
       2.1.7.1 Contract for New or Modified Electricity Service------------------------31
       2.1.7.2 Implied Contract----------------------------------------------------------32
       2.1.7.3 Special Contracts----------------------------------------------------------32
       2.1.7.4 Connection Agreements-----------------------------------------------------32
       2.1.7.5 Payment by Building Owner--------------------------------------------------33
       2.1.7.6 Opening and Closing of Accounts-------------------------------------------34

2.2 Disconnection-------------------------------------------------------------------34
   2.2.1 Disconnection & Reconnection – Process and Charges--------------------------35
   2.2.2 Unauthorized Energy Use-------------------------------------------------------37
TABLE OF CONTENTS

2.3 Conveyance of Electricity

2.3.1 Limitations on the Guaranty of Supply

2.3.2 Power Quality

2.3.2.1 Power Quality Testing

2.3.2.2 Prevention of Distortion on the Distribution System

2.3.2.2.1 Voltage Distortion

2.3.2.2.2 Current Distortion

2.3.2.3 Obligation to Help in the Investigation

2.3.2.4 Timely Correction of Deficiencies

2.3.2.5 Notification for Interruptions

2.3.2.6 Notification to Consumers on Life Support

2.3.2.7 Emergency Interruptions for Safety

2.3.2.8 Emergency Service (Trouble Calls)

2.3.2.9 Outage Reporting

2.3.3 Electrical Disturbances

2.3.4 Standard Voltage Offerings

2.3.4.1 Primary Voltage

2.3.4.2 Supply Voltage

2.3.4.3 Multiple Connections to Main Distribution System

2.3.5 Voltage Guidelines

2.3.6 Emergency Backup Generation Facilities

2.3.7 Metering

2.3.7.1 General

2.3.7.1.1 Metering Requirements for Multi-Unit Residential Rental Buildings and Condominiums

2.3.7.1.2 Main Switch and Meter Mounting Devices

2.3.7.1.3 Service Mains Limitations

2.3.7.1.4 Special Enclosures

2.3.7.1.5 Meter Cables

2.3.7.1.6 Barriers

2.3.7.1.7 Doors

2.3.7.1.8 Auxiliary Connections

2.3.7.1.9 Working Space

2.3.7.2 Current Transformer Boxes

2.3.7.3 Interval Metering

2.3.7.4 Meter Reading

2.3.7.5 Final Meter Reading

2.3.7.6 Faulty Registration of Meters

2.3.7.7 Meter Dispute Testing

2.4 Tariffs and Charges

2.4.1 Service Connection

2.4.1.1 Customers Switching to Retailer

2.4.2 Energy Supply

2.4.2.1 Standard Service Supply (SSS)

2.4.2.2 Retailer Supply

2.4.2.3 Wheeling of Energy

2.4.3 Deposits

2.4.4 Billing

2.4.5 Payments and Overdue Account Interest Charges

2.4.6 Credit Refunds to Customer

2.5 Customer Information

2.6 Temporary Services

3 CUSTOMER CLASS SPECIFIC

---

65
TABLE OF CONTENTS

3.1 Residential ................................................................................................................. 65
  3.1.1 Overhead Services ............................................................................................... 65
    3.1.1.1 Minimum Requirements .............................................................................. 65
    3.1.1.2 Services Over Swimming Pools ................................................................... 67
  3.1.2 Underground Services for Individual Residences .................................................. 67

3.2 General Service .......................................................................................................... 68
  3.2.1 Electrical Requirements (as applicable) ............................................................. 70
  3.2.2 Underground Service Requirements ................................................................... 71

3.3 General Service (Above 50 kW) ................................................................................. 72
  3.3.1 New Residential Subdivisions or Multi-Unit Developments .................................. 72
  3.3.2 Electrical Requirements .................................................................................... 72
  3.3.3 Technical Information ....................................................................................... 74
    3.3.3.1 Site & Grading Plans .................................................................................. 74
    3.3.3.2 Mechanical Servicing Plan ........................................................................ 74
    3.3.3.3 Floor Plan .................................................................................................... 74
    3.3.3.4 Duct Bank Location ..................................................................................... 74
    3.3.3.5 Transformer Location .................................................................................. 75
    3.3.3.6 Electrical Meter Room ................................................................................ 75
    3.3.3.7 Single Line Diagram .................................................................................... 75
    3.3.3.8 Switchgear .................................................................................................. 75
    3.3.3.9 Substation Information ................................................................................ 75
  3.3.4 Technical Considerations ..................................................................................... 76
    3.3.4.1 Short Circuit Ratings .................................................................................. 76
    3.3.4.2 Primary Fusing ............................................................................................ 76
    3.3.4.3 Ground Fault Interrupting .......................................................................... 76
    3.3.4.4 Lightning Arresters ..................................................................................... 77
    3.3.4.5 Basic Impulse Level (B.I.L.) ...................................................................... 77
    3.3.4.6 Unbalanced Loads ....................................................................................... 77

3.4 General Service (Above 1000 kW) ............................................................................. 77
  3.4.1 Electrical Requirements ...................................................................................... 77
  3.4.2 Technical Information and Considerations .......................................................... 78

3.5 Embedded Generation Facilities ................................................................................. 78

3.6 Wholesale Market Participant ...................................................................................... 79

3.7 Embedded Distributor .................................................................................................. 79

3.8 Unmetered Connections .............................................................................................. 79
  3.8.1 Street Lighting .................................................................................................... 81
  3.8.2 Traffic & Railway Crossing Signals, Pedestrian X-Walk Signals/Beacons, Bus Shelters, Telephone Booths, CATV Amplifiers, TTC Switching Devices, and Miscellaneous Small Fixed Loads ...................................................................................................................... 82
  3.8.3 Other Loads (<2 kW) - Decorative Lighting and Tree Lighting Services ............ 83

4 GLOSSARY OF TERMS ................................................................................................. 84

5 TABLES .......................................................................................................................... 95

TABLE 1.1 Demarcation Points & Charges for Connection Assets and Disconnection ........ 96

TABLE 1.2 Demarcation Points & Charges for Connection Assets and Disconnection ........ 97

4
TABLE OF CONTENTS

TABLE 1.3  Demarcation Points & Charges for Connection Assets and Disconnection .................................. 98
TABLE 1.4  Demarcation Points & Charges for Connection Assets and Disconnection .................................. 99
TABLE 2  Service Connection and Disconnection Fee .................................................................................. 100
TABLE 3  New or Upgraded Street Lighting Services – Point of Demarcation and Connection Charges- 102
TABLE 4  Customer-Owned Transformers (Article 3.4.1) ............................................................................. 103
TABLE 5  Meter Sockets (Article 2.3.7.1.2) ............................................................................................... 104
TABLE 6  Meter Cabinets (Article 2.3.7.1.2) ............................................................................................ 105
TABLE 7  Instrument Transformers and Enclosures (Article 2.3.7.2) .......................................................... 106
TABLE 8  Meter Centres (Article 2.3.7.1.2) ............................................................................................... 107
TABLE 9.2 – Toronto Hydro / Customer Interactions for Table 9.1 Process Map: Customer Connection/Transfer/Disconnection/Removal Services .................................................................................. 109
TABLE 9.2 – Toronto Hydro / Customer Interactions for Table 9.1 Process Map: Customer Connection/Transfer/Disconnection/Removal Services (continued) .............................................................................. 110
TABLE 9.3 – Unmetered Scatter Load Process Map: Existing Customer Service Updates and Validation 111
TABLE 9.4 – Toronto Hydro / Customer Interactions for Table 9.3 Process Map: Existing Customer Service Updates and Validation ............................................................................................................ 112

6 REFERENCES............................................................................................................................................ 113
1. Economic Evaluation Model for Distribution System Expansion ......................................................... 113
2. Standard Toronto Hydro Connection Agreements - Terms of Conditions .................................................. 113
3. Toronto Hydro Distributed Generation Requirements .............................................................................. 113
4. Toronto Hydro Requirements for the Design and Construction of Customer-Owned High Voltage Substations ............................................................................................................................................. 113
5. Toronto Hydro Requirements for the Design and Construction of Customer-Owned Structures 113
6. Toronto Hydro Metering Requirements 750 Volts or Less ................................................................... 113
7. Toronto Hydro Metering Requirements for 13.8 kV & 27.6 kV Customer-Owned Substations ... 113
8. Contractor Pre-Qualification Application ............................................................................................... 113
9. Toronto Hydro Metering Services and Charges .................................................................................. 113
Section 1 – INTRODUCTION

1 INTRODUCTION

1.1 Identification of Distributor and Service Area

In this section the distributor should identify its service area as defined in the Distributor’s License.

Toronto Hydro-Electric System Limited, referred to herein as “Toronto Hydro,” is a corporation incorporated under the laws of the Province of Ontario and a distributor of electricity.

Toronto Hydro is licensed by the Ontario Energy Board (“OEB”) to supply electricity to Customers as described in the Electricity Distribution License issued to Toronto Hydro on October 17, 2003 by the OEB and expiring October 16, 2023 (“Distribution License”). Additionally, there are requirements imposed on Toronto Hydro by the various codes referred to in the Distribution License and by the Electricity Act, 1998 and the Ontario Energy Board Act, 1998.

Toronto Hydro may only operate distribution facilities within its Licensed Territory as defined in its Distribution License. This service area is subject to change with the OEB’s approval.

Nothing contained in these Conditions of Service or in any contract for the supply of electricity by Toronto Hydro shall prejudice or affect any rights, privileges, or powers vested in Toronto Hydro by law under any Act of the Legislature of Ontario or the Parliament of Canada, or any regulations thereunder.

1.1.1 Distribution Overview

Toronto Hydro distributes electrical power through 13.8 kV and 27.6 kV primary distribution systems. On the 27.6 kV system all feeders are arranged to run in an open-loop fashion with open points between adjacent feeders. These feeders supply distribution transformers either directly or through 13.8 kV or 4 kV sub-distribution systems. There are presently four types of distribution design systems at the 13.8 kV primary voltage level:

- 13.8 kV underground radial
- 13.8 kV overhead open loop
- 13.8 kV underground open-loop
- 13.8 kV underground network

The underground network system is distinct from the other systems. This low-voltage secondary network system may be available to some Customers in the downtown core of the City of Toronto as a source of supply at 120/208 V or
Conditions of Service

Section 1 – INTRODUCTION

347/600 V, depending on the local capacity of the system and the energy requirements of the Customer.

The supply of electricity by Toronto Hydro to any Customer will be at one of the following primary voltage levels: 27.6 kV or 13.8 kV depending on the proximity of the Customer’s premises to the nearest distribution facility. For connection of a Customer at 4 kV level, Toronto Hydro will carry out a special study to justify the investment. The cost of this study may be charged to the Customer.

Each type of supply is distinct and is suitable for different Customer classes and geographic areas. Toronto Hydro will determine, at its sole discretion, the Customer’s type of supply based on factors that include, but are not limited to, reliability, capacity, operational and system design considerations.

1.2 Related Codes and Governing Laws

This section should reference any legislation that is applicable to the distributor – Customer relationship.

The supply of electricity or related services by Toronto Hydro to any Customer or Consumer shall be subject to various laws, regulations, and codes, including the provisions of the latest editions of the following acts, codes and licences:

1. *Electricity Act, 1998* } part of the Energy Competition
3. Distribution Licence
4. Affiliate Relationships Code
5. Transmission System Code
6. Distribution System Code
7. Retail Settlement Code

In the event of a conflict between this document and the Distribution License or regulatory codes issued by the OEB, or the Energy Competition Act, 1998 (the “Act”), the provisions of the Act, the Distribution License and associated regulatory codes shall prevail in the order of priority indicated above.

When planning and designing for electricity service, Customers and their agents must refer to all applicable provincial and Canadian electrical codes, and all other applicable federal, provincial, and municipal laws, regulations, codes and by-laws to also ensure compliance with their requirements. Without limiting the foregoing, the work shall be conducted in accordance with the latest edition of the *Ontario Occupational Health and Safety Act* (OHSA); O. Reg. 213/91: Construction Projects under the OHSA; and the Electrical Utility Safety Rules published by the Infrastructure Health and Safety Association (IHSA).
Section 1 – INTRODUCTION

1.3 Interpretations

This section should describe the rules for interpretation of the Conditions of Service document.

In these Conditions of Service, unless the context otherwise requires:

- Headings, paragraph numbers and underlining are for convenience only and do not affect the interpretation of these Conditions of Service;
- Words referring to the singular include the plural and vice versa;
- Words referring to a gender include any gender.

1.4 Amendments and Changes

This section should outline the process for making changes to this document. Include any public notice provisions.

The provisions of these Conditions of Service in effect at the time Toronto Hydro signs the contract shall form part of any contract made between Toronto Hydro and any connected Customer, Consumer or Retailer. These Conditions of Service supercedes all previous conditions of service, oral or written, of Toronto Hydro including any of its predecessor municipal electric utilities as of its effective date.

In the event of changes to these Conditions of Service, Toronto Hydro will issue a notice with the Consumer’s bill. Toronto Hydro may also issue a public notice in a local newspaper.

The Customer is responsible for contacting Toronto Hydro to obtain the current version of these Conditions of Service. Toronto Hydro may charge a reasonable fee for providing the Customer with a copy of this document. The current version of this document is also posted on the Toronto Hydro website and can be downloaded from www.torontohydro.com.

1.5 Contact Information

This section should provide information on how a Customer can contact the distributor. Include such items as:

- Address of the distributor,
- Telephone numbers,
- Normal business hours, and
- Emergency contact numbers.

Toronto Hydro can be contacted 24 hours a day at 416-542-8000 or such other numbers as Toronto Hydro may advise through its website, invoices or otherwise. Except where otherwise noted, normal working hours are Monday to Friday.
Section 1 – INTRODUCTION

between 8:30 a.m. and 4:30 p.m. Customer Care representatives may be contacted at 416-542-8000 between 8:00 a.m. and 8:00 p.m. Monday to Friday. The mailing address is Toronto Hydro-Electric System Limited, 14 Carlton Street, Toronto Ontario M5B 1K5.

1.6 Customer Rights

This section should outline the rights and obligations a Customer or embedded generator has with respect to the distributor that are not covered elsewhere in this document.

Toronto Hydro shall only be liable to a Customer and a Customer shall only be liable to Toronto Hydro for any damages that arise directly out of the willful misconduct or negligence:

- of Toronto Hydro in providing distribution services to the Customer;
- of the Customer in being connected to Toronto Hydro’s distribution system; or
- of Toronto Hydro or Customer in meeting their respective obligations under these Conditions of Service, their licences and any other applicable law.

Notwithstanding the above, neither Toronto Hydro nor the Customer shall be liable under any circumstances whatsoever for any loss of profits or revenues, business interruption losses, loss of contract or loss of goodwill, or for any indirect, consequential, incidental or special damages, including but not limited to punitive or exemplary damages, whether any of the said liability, loss or damages arise in contract, tort or otherwise.

The Customer shall indemnify and hold harmless Toronto Hydro, its directors, officers, employees and agents from any claims made by any third parties in connection with the construction and installation of an embedded generation facility or other electrical apparatus by or on behalf of the Customer.

1.7 Distributor Rights

This section should outline the rights a distributor has with respect to a Customer or embedded generator that are not covered elsewhere in this document.

1.7.1 Access to Customer Property

Toronto Hydro shall have access to Customer’s property in accordance with Section 40 of the Electricity Act, 1998.

For further clarity, Toronto Hydro has the right to safe, secure, unobstructed, and unimpeded access to Toronto Hydro distribution equipment on, under, over or inside Customer-Owned property, twenty-four (24) hours a day seven (7) days a
Section 1 – INTRODUCTION

week. Toronto Hydro will provide reasonable notice of entry, which under certain situations may result in no notice being provided, including:

1. during an emergency situation; or
2. when access without notification has been previously agreed upon by and arranged between Toronto Hydro and the Customer.

When access is obstructed or impeded, Toronto Hydro may at its sole discretion remove the obstruction or the impediment (e.g., removal of unauthorized locks) in order to gain access to its distribution equipment, and Toronto Hydro shall not be liable to the Customer for any damages arising as a result of the removal of the obstruction or the impediment other than physical damage to facilities arising directly from entry on the Customer’s property.

1.7.2 Safety of Equipment

The Customer shall comply with all aspects of the Ontario Electrical Safety Code with respect to insuring that equipment is properly identified and connected for metering and operation purposes and will take whatever steps necessary to correct any deficiencies, in particular cross wiring situations, in a timely fashion. If the Customer does not take such action within a reasonable time, Toronto Hydro may disconnect the supply of electricity to the Customer.

The Customer shall not use or interfere with the facilities of Toronto Hydro except in accordance with a written agreement with Toronto Hydro. Toronto Hydro has the right to seal any point where a connection may be made on the line side of the metering equipment.

The Customer shall not build, plant or maintain or cause to be built, planted or maintained any structure or object (including but not limited to trees, shrubs, landscaping, fencing, parked vehicles, and patios) that, in the sole opinion of Toronto Hydro or other municipal or regulatory authority, would or could obstruct the running of distribution lines; endanger or impair access to Toronto Hydro’s equipment; interfere with the proper and safe operation of Toronto Hydro’s facilities, including the timely maintenance or response to system or equipment issues; or adversely affect compliance with any applicable legislative, regulatory or municipal requirement. Where an obstruction is discovered, Toronto Hydro will notify the Customer and provide a reasonable time for the Customer to correct any obstructions. If the Customer does not remove such obstruction within the reasonable time designated by Toronto Hydro, Toronto Hydro may disconnect the supply of electricity to the Customer and/or remove, relocate or, in the case of shrubs or other vegetation, trim such obstructions at the Customer's expense, and Toronto Hydro shall not be liable to the Customer for any damages arising as a result thereof, other than physical damage to facilities arising directly from entry on the Customer’s property. Toronto Hydro's policies and procedures
with respect to the disconnection process are further described in these Conditions of Service.

1.7.3 Tree and Vegetation Management

To ensure public safety and the continued reliable operation of its distribution system Toronto Hydro will maintain clearance around its distribution lines on a cyclical or as-needed basis in close cooperation with the City’s forestry department. The tree trimming cycle may vary depending on extent of storm damage, health of trees, and vegetation type.

Toronto Hydro will coordinate and maintain tree clearance around all its distribution lines that are located on the public road allowance. Toronto Hydro will also maintain tree clearance around its overhead lines over 750 Volts that may be located on private property at no cost to the Customer. Toronto Hydro will endeavour to discuss the planned re-clearing with property owners prior to work being performed in order to mitigate the impacts to the environment and the property. However, in the event of emergencies, Toronto Hydro may be unable to notify the property owner prior to performing the work.

Customers are responsible for all initial tree trimming for all new overhead lines that will be located on private property. Customers are also responsible for continuing tree trimming, tree and brush removal around service lines that are less than 750 Volts that are located on private property as well as around overhead lines over 750 Volts when these lines are owned by the Customer. Clearances must conform to the Electrical Safety Code.

To permit the safe clearance of trees and vegetation from Customer-Owned overhead lines over 750 Volts located on private property, Customers are required to contact Toronto Hydro to request and pay for the disconnection and reconnection of the electricity supply prior to performing work.

1.7.4 Operating Control

The Customer shall provide a convenient and safe place, satisfactory to Toronto Hydro, for installing, maintaining and operating its equipment in, on, or about the Customer's premises or in, on, or about the public road allowance for non-metered connections. Toronto Hydro assumes no risk and will not be liable for damages resulting from the presence of its equipment on the Customer’s premises or in, on, or about the public road allowance for non-metered connections, or approaches thereto, or any acts, omissions or events beyond its control, or the negligence or willful misconduct of any Persons over whom Toronto Hydro has no control.
Section 1 – INTRODUCTION

Unless an employee or an agent of Toronto Hydro, or other Person lawfully entitled to do so, no Person shall remove, replace, alter, repair, inspect or tamper with Toronto Hydro’s equipment.

Customers will be required to pay the cost of repairs or replacement of Toronto Hydro’s equipment that has been damaged or lost by the direct or indirect act or omission of the Customer or its agents.

The physical location on Customer's premises or the public road allowance for non-metered connections at which a distributor’s responsibility for operational control of distribution equipment ends is defined by the Distribution System Code as the “operational demarcation point”.

1.7.5 Customer-Owned Equipment, Infrastructure, and Property

The Customer is responsible for providing, inspecting, maintaining, repairing and replacing, in a safe condition satisfactory to Toronto Hydro, all equipment and infrastructure that is owned by the Customer on private property or in the public road allowance for non-metered connections. Equipment and infrastructure includes but is not limited to transformers, cable, switches, poles, fences, gates, duct banks, conduits, cable chambers, cable pull rooms, transformer rooms, transformer vaults, transformer pads, tap boxes, handwells, service masts, and junction boxes.

The Customer is also responsible for maintaining its property in a condition that is safe and that does not inhibit the operation or threaten the integrity or reliability of equipment or infrastructure owned by the Customer or Toronto Hydro. The Customer’s responsibility to maintain its property includes, but is not limited to, clearing vegetation, keeping storm drains clear and drainage systems fully functional, removing debris, maintaining operational and electrical clearances, and maintaining proper grading and surfaces.

The Customer shall inspect and maintain its equipment, infrastructure, and property at regular intervals. When access to the equipment, infrastructure, or property is under the control of Toronto Hydro (e.g. a transformer vault, a fenced off transformer), the Customer shall contact Toronto Hydro as per the instructions posted on Toronto Hydro’s website to make appropriate arrangements (e.g. access, temporary disconnection) prior to undertaking any inspections, maintenance, repairs, or replacements.

For Customer-Owned vaults that contain Toronto Hydro equipment, Toronto Hydro will provide a Customer with one vault access every 12 months at no charge. This no charge service would be scheduled during Toronto Hydro’s normal working hours, and appointment times are not necessarily guaranteed.
Section 1 – INTRODUCTION

Vault access at times other than during Toronto Hydro’s normal working hours will be charged at cost. If Toronto Hydro staff attend to provide no charge vault access and the Customer is not present, Toronto Hydro will not provide an additional no charge vault access during the 12 month period and may charge the Customer for attending the site.

If the Customer does not inspect, maintain, repair, or replace its equipment, infrastructure, and property as required, Toronto Hydro may disconnect the supply of electricity to the Customer.

Notwithstanding the above, unless otherwise agreed to by the parties, subject to the Customer providing an easement to Toronto Hydro, Toronto Hydro will provide, maintain, repair and replace those civil infrastructure (such as poles, duct banks, conduits, cable chambers, cable pull rooms, transformer vaults, transformer pads, and switching vaults) that are required to house the primary distribution systems built along private streets that supply Customers of Multi-unit Residential developments (part of Class 3B). Effective November 15, 2004, Toronto Hydro will treat such infrastructure in the same way as those located in the public road allowance.

Where Toronto Hydro identifies, through an inspection or other activity, deficiencies relating to the equipment, infrastructure, or property owned by the Customer, such as deficiencies to walls, ceilings, floors, doors, vents, drains, electrical devices or other elements, Toronto Hydro may:

- notify the Customer of the deficiencies;
- provide a reasonable time for the Customer to correct the deficiencies; and
- if circumstances merit, request the Customer to correct the deficiency in a manner that brings the equipment, infrastructure, or property up to current standards even if the equipment, infrastructure, or property was designed, installed, or constructed to an older standard. (Examples of circumstances that may merit the application of a current standard include, but are not limited to, the existence of health or safety hazards, legal or regulatory requirements, and conditions that may impact the integrity, reliability, or operability of the distribution system or any equipment that supplies the Customer.)

If notified of deficiencies, or requested to correct deficiencies in a particular manner, the Customer shall correct the deficiencies and comply with any requests. If the Customer does not correct the deficiencies within the reasonable time, or if the corrections are not considered adequate by Toronto Hydro or an inspection authority, Toronto Hydro may disconnect the supply of electricity to the Customer or may correct the deficiencies at the Customer's expense, and Toronto Hydro shall not be liable to the Customer for any damages arising as a result of or in the course of disconnecting supply or correcting the deficiencies other than physical
Section 1 – INTRODUCTION

damage to facilities arising directly from entry on the Customer’s property. Toronto Hydro’s policies and procedures with respect to the disconnection process are further described in these Conditions of Service.

Notwithstanding the above, the Customer shall be liable for any damages or losses sustained by Toronto Hydro, including damages to Toronto Hydro equipment and infrastructure that is installed either within the public road allowance or private property, resulting from:

- the operation or failure of Customer-Owned equipment,
- the Customer not adequately maintaining, repairing, or replacing their infrastructure,
- the Customer not adequately maintaining or repairing their property.

1.8 Disputes

*Any dispute between Customers or Retailers and the Distributor shall be settled according to the dispute resolution process specified in the Distributor Licence. In this section, the Distributor should outline the Customer Complaint and Dispute Resolution process that has been established as a condition of licence.*

If a Customer, Consumer or other market participant has a complaint about Toronto Hydro regarding services provided by Toronto Hydro under its Electricity Distribution License, the Consumer may contact Toronto Hydro’s Customer Care Department by telephone at 416-542-8000 Monday to Friday from 8:00 a.m. – 8:00 p.m., or by email through the Contact section of Toronto Hydro’s website (www.torontohydro.com), or through a fax at 416-542-3429, or in writing at:

Toronto Hydro
Attn: Customer Care
500 Commissioners Street
Toronto, ON
M4M 3N7

Upon receipt of a complaint, a Toronto Hydro Customer Care representative will contact the Customer, Consumer or other market participant to acknowledge receipt of the complaint and, if possible, to resolve the complaint. If a Customer, Consumer or other market participant is not satisfied with the resolution, they may follow the Dispute Resolution process described on Toronto Hydro’s website (http://www.torontohydro.com/sites/electricsystem/residential/customercare/Pages/DisputeResolutionProcess.aspx).
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

2  DISTRIBUTION ACTIVITIES (GENERAL)

This section should include information that is applicable to all Customer classes of the distributor. Items that are applicable to only a specific Customer class are covered in Section 3.

2.1  Connections - Process and Timing

Under the terms of the Distribution System Code, Toronto Hydro has the obligation to either connect or to make an offer to connect any Customers that lie in its service area. The form of the offer and its terms and conditions may vary in accordance with Toronto Hydro’s requirements for connecting a Customer to Toronto Hydro’s distribution system.

The Customer or its representative shall consult with Toronto Hydro concerning the availability of supply, the supply voltage, service location, metering, and any other details. These requirements are separate from and in addition to those of the Electrical Safety Authority (ESA). Toronto Hydro will confirm, in writing, the characteristics of the electricity supply.

The Customer or its authorized representative shall apply for new or upgraded electricity services and temporary power services in writing. The Customer is required to provide Toronto Hydro with sufficient lead-time in order to ensure:

- the timely provision of electricity supply to new and upgraded premises or
- the availability of adequate capacity for additional loads to be connected in existing premises.

Toronto Hydro shall make every reasonable effort to respond promptly to a Customer’s request for connection. Toronto Hydro shall respond to a Customer’s written request for a Customer connection within 15 calendar days of receipt of the written request. Toronto Hydro will make an offer to connect within 60 calendar days of receipt of the written request, unless other necessary information is required from the Customer before the offer can be made.

Toronto Hydro may collect a Design Pre-payment in order to initiate and perform a design review in the preparation of an offer to connect. Upon acceptance of the offer to connect, the Design Pre-payment will be credited towards the Customer’s financial obligations for the project. If the Customer does not accept Toronto Hydro’s offer to connect, or if the applicant withdraws its application, or if Toronto Hydro is unable to provide an offer to connect, then Toronto Hydro may refund the Design Pre-payment less any costs incurred by Toronto Hydro.

Toronto Hydro shall make every reasonable effort to respond promptly to another distributor’s request for connection. Toronto Hydro shall provide an initial consultation with another distributor regarding the connection process within thirty
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

(30) days of receiving a written request for connection. A final offer to connect the distributor to Toronto Hydro’s distribution system shall be made within ninety (90) days of receiving the written request for connection, unless other necessary information outside the distributor’s control is required before the offer can be made.

If special equipment is required or equipment delivery problems occur, then longer lead times may be necessary. Toronto Hydro will notify the Customer of any extended lead times.

In addition to any other requirements in these Conditions of Service, the supply of electricity is conditional upon Toronto Hydro being permitted and able to provide such a supply, obtaining the necessary apparatus, material, and easements, and constructing works to provide the service. Should Toronto Hydro not be permitted or able to do so, it is under no responsibility to the Customer whatsoever and the Customer releases Toronto Hydro from any liability in respect thereto.

Requirements regarding Connection Agreements are set forth in Sections 2.1.7.4, 3.7, and in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements” for load Customer, a Generator, Wholesale Market Participant, and Embedded Distributor.

2.1.1 Building that Lies Along

In this section, the Distributor should describe the standard connection allowance or charge used by the Distributor in its service territory, and describe any variable connection fees that would be charged beyond the standard allowance. The Distributor also may stipulate in this section other terms and conditions by which a Customer requesting a Connection must abide, as long as it is within the terms of the DSC code.

For the purpose of these Conditions of Service "lies along" means a Customer property or parcel of land that is directly adjacent to or abuts onto the public road allowance where Toronto Hydro has distribution facilities of the appropriate voltage and capacity.

Under the terms of the Distribution System Code, Toronto Hydro has the obligation to connect (under Section 28 of the Electricity Act, 1998) a building or facility that “lies along” its distribution line, provided:

a) the building can be connected to Toronto Hydro’s distribution system without an expansion or enhancement and,

b) the service installation meets the conditions listed in the Conditions of Service of the distributor that owns and operates the distribution line.

The location of the Customer’s service entrance equipment is subject to the approval of Toronto Hydro and the Electrical Safety Authority.
2.1.1.1 Connection Charges

Toronto Hydro shall recover costs associated with the installation of connection assets by Customer Class via Basic Connection Costs through the economic evaluation for Expansions and Variable Connection Costs, collected directly from the Customer, as applicable.

The Variable Connection Costs shall be calculated as the costs associated with the installation of Connection assets above and beyond the Standard Allowance for Basic Connection as described in Tables 1.1, 1.2, 1.3, and 1.4. Toronto Hydro will recover these Variable Connection Costs, which shall be based on actual cost, directly from the Customer.

2.1.2 Expansions / Offer to Connect

Under the terms of the DSC, a Distributor has the Obligation to make an Offer to Connect any Building that is in the distributor’s service territory that cannot be connected without an expansion, or “lies along” its distribution system, but may be denied connection for the reasons described in subsection 2.1.3 of the distributor’s Conditions of Service.

The Offer to Connect must be fair and reasonable and be based on the distributor’s design standard. The Offer to Connect also must be made within a reasonable time from the request for connection.

In this section, the Distributor should outline, in detail, the process followed to determine any required capital contributions. This section also should describe any fixed connection fees as well as variable connection fees, by Customer class.

If a Customer requests to connect a new Customer load, either through a new connection or by increasing the load at an existing connection, to Toronto Hydro’s distribution system, and the new load necessitates an expansion of Toronto Hydro’s distribution system, then Toronto Hydro will provide Customers requesting connections that necessitate an expansion with an offer to connect for expansions (“Offer to Connect”). Toronto Hydro will perform an economic evaluation of the expansion project in accordance with the Capital Contribution policy set out in Section 2.1.2.2. The economic evaluation will determine if the forecasted future revenue (“Estimated Incremental Revenues”) from the new load (“Estimated Incremental Demand”) and from the Customer(s) will pay for the costs associated with the expansion. The costs associated with the expansion include but are not limited to:

1) the distribution system expansion capital cost “Expansion Costs”;
2) on-going operating, maintenance and administration costs including those actually incurred and those apportioned in the manner set forth below “OM&A Costs”; and
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

3) the basic cost of connection outlined in Tables 1.1, 1.2, and 1.3 “Basic Connection Costs”.

The Expansion Costs that Toronto Hydro will include in the economic evaluation are capital costs that are associated with the installation of expansion facilities and equipment on Toronto Hydro’s main distribution system. The expansion facilities and equipment will typically meet the following criteria:

- Are required to accommodate the new Customer load;
- Are not necessary to serve the needs of existing Customers and their existing loads; and
- Are designed and installed in accordance with Toronto Hydro’s planning, design, and construction standards.

For the purpose of determining OM&A Costs, Toronto Hydro will use system average operating, maintenance and administrative costs as a proxy for incremental OM&A Costs associated with the expansion facilities and apportion them as fixed costs (for Rate Class 1 and 2) or as a function of $/kW of demand (for Rate Class 3, 4, and 5).

The Expansion Costs are in addition to any Variable Connection Costs. Refer to Table 1.1, 1.2, and 1.3 in Section 5 for each Customer Class.

For the purpose of establishing the Estimated Incremental Demand to be used in the economic evaluation, the Customer shall provide a valid estimate of the proposed new load (incremental demand) for evaluation and acceptance by Toronto Hydro. If the Customer and Toronto Hydro are unable to agree on a valid incremental demand for new Class 3, 4, and 5 Customers or in the absence of adequate billing history for existing Customers, Toronto Hydro will set the Estimated Incremental Demand to 90% of the incremental installed transformer capacity.

Using the Estimated Incremental Demand, Toronto Hydro shall then calculate the Estimated Incremental Revenues that would be received from the Customer(s) based on the new load. Toronto Hydro will use the “fixed charge” and the “variable charge” that have been approved by the Ontario Energy Board by Rate Class to determine the Estimated Incremental Revenues. For existing Customers Toronto Hydro shall apportion the “fixed charge” based on the ratio between the new (incremental) load and the combined load.

In performing the economic evaluation, should the Net Present Value (NPV) of the costs and revenues associated with the Expansion be less than zero, the Customer shall pay a capital contribution in the amount of the shortfall (i.e. the amount below zero) to Toronto Hydro. Toronto Hydro has elected to collect this shortfall from the
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Customer in accordance with its Capital Contribution policy as outlined in Section 2.1.2.2.

For the purposes of connecting a generator, the amount charged by Toronto Hydro to the generator to construct an expansion to connect a generation facility to the Toronto Hydro distribution system shall not exceed the generator’s share of the present value of the projected capital costs and on-going maintenance costs for the equipment. Projected revenue and avoided costs from the generation facility shall be assumed to be zero, unless otherwise determined by rates approved by the Ontario Energy Board. In the case of a renewable energy generation facility, Toronto Hydro shall not charge the generator for any costs of the expansion that are at or below the renewable energy expansion costs cap for renewable energy generation facilities as set by the Ontario Energy Board.

The methodology and inputs that Toronto Hydro will use for all new load and new connection economic evaluations are presented in Appendix B of the Distribution System Code.

2.1.2.1  Offer to Connect & Alternative Bid Work

Toronto Hydro will provide one firm Offer to Connect to the Customer, at no expense to the Customer, for plans submitted to Toronto Hydro that necessitate an expansion to Toronto Hydro’s main distribution system. If the Customer submits revised plans, Toronto Hydro may provide a new firm Offer to Connect for the revised plans at the Customer’s expense.

In the Offer to Connect, Toronto Hydro will advise the Customer of any eligible work for which the Customer has the choice to obtain alternative bids from a qualified contractor. The Customer may obtain an alternative bid to construct the eligible work portions of the expansion and connection facilities:

- that do not make physical contact with Toronto Hydro’s distribution system; and
- that only require work to be completed within Toronto Hydro’s safe limits of approach to energized facilities or equipment,

unless otherwise directed by Toronto Hydro.

If the Customer chooses to utilize an alternative bid, the Customer shall only use qualified contractors. To qualify to undertake work that is eligible for alternative bid, contractors shall submit a “Contractor Pre-Qualification Application” (refer to Section 6) and meet the requirements no later than 30 business days prior to their selection by the Customer to undertake work that is eligible for alternative bid. To avoid delay in the start of the work that is
eligible for alternative bid, the Customer shall engage a contractor that is qualified.

Toronto Hydro does not make any representation or warranty regarding any contractor selected by the Customer to do any work regardless of whether the contractor has completed the requirements set by Toronto Hydro or not and shall have no liability to the Customer in respect of such work.

Toronto Hydro will also include in the Offer to Connect or by separate document an estimate of any additional costs ("Additional Alternative Bid Costs") that will be incurred by Toronto Hydro in the event that the Customer decides to pursue an alternative bid for the work that is eligible for alternative bid. Additional Alternative Bid Costs may include, but are not limited to, the following:

- costs for additional design, engineering, or installation of facilities required to complete the project;
- costs associated with any temporary de-energization of any portion of the existing distribution system that is required in relation to an expansion that is constructed under the alternative bid option;
- costs associated to review and approve the plans for the design, engineering, layout, and work execution for the work that is eligible for alternative bid to ensure conformance to Toronto Hydro’s distribution system planning standards and specifications prior to commencing that work;
- costs for administering the contract between the Customer and the contractor hired by the Customer if Toronto Hydro is asked to administer the contract by the Customer and Toronto Hydro agrees to administer the contract; and
- costs for inspection or approval by Toronto Hydro of the work performed by the contractor hired by the Customer.

Within sixty (60) days of receiving the Offer to Connect, the Customer shall return a signed copy of the Offer to Connect indicating the Customer has accepted the offer, and whether the Customer is electing to pursue an alternative bid. After sixty (60) days, if the Customer has not accepted the Offer to Connect in writing, Toronto Hydro may revoke the Offer to Connect without providing any notification to the Customer.

If the Customer decides to pursue an alternative bid, the Customer and his qualified contractor shall only use materials that meet the same specifications as Toronto Hydro approved materials (i.e. same manufacturers and same part numbers). Once the Customer has hired a qualified contractor, the Customer may request, and if requested, Toronto Hydro shall provide the listing of approved materials that may be required for the alternative bid work.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Upon accepting an Offer to Connect, regardless of whether the Customer will be pursuing an alternative bid or not, the Customer shall provide Toronto Hydro the payables (e.g. costs) and security amounts (e.g. deposits) as required and stipulated in the Offer to Connect.

2.1.2.2 Capital Contribution Policy

The capital contribution policy elected by Toronto Hydro shall be consistent with the policy outlined below for each Customer Class:

Class 1 – Residential Single Service: No Transformation required on private property

- Overhead or Underground: *Capital contribution not collected from Customer*

Class 2 - General Service, (Below 50 kW): No Transformation required on private property

- Overhead or Underground: *Capital contribution not collected from Customer*

Class 3 - General Service (50 kW – 999 kW): Capital contribution collected from Customer

Class 4 - General Service (1000 kW – 4999 kW): Capital contribution collected from Customer

Class 5 – Large User (5000 kW and above): Capital contribution collected from Customer

For the purpose of determining the amount of Capital Contribution payable by a Customer the following clarification and exception shall apply:

- Condominium apartments and apartment buildings that have a demand less than 1,000 kW are part of Class 3A General Services
- Condominium townhouse units intended to remain in private property are part of Class 3B General Service
- Townhouse units built (or intended to be) fronting public road allowances are part of Class 3C “Residential Subdivision”
- Townhouse units built as “freehold” (i.e. on property owned by the individual townhouse owner) are part of Class 3C “Residential Subdivision”
- Low-rise residential developments involving more than 5 lots regardless of demand are classified as Class 3C “Residential Subdivision”.
However, notwithstanding the treatment of capital contribution, Toronto Hydro shall in all cases calculate the “Estimated Incremental Revenues” of new Customers using the “fixed charge” and the “variable charge” that have been approved by the Ontario Energy Board for the Rate Class applicable to each individual new meter installed in connection with the expansion project.

To determine the amount of Capital Contribution required from a Class 3, 4, or 5 Customer for an expansion project, Toronto Hydro will perform an economic evaluation by inputting the project specific information together with a set of standardized assumptions and specific annual parameters into a proprietary “Business Economic Model” developed for Toronto Hydro in accordance with the methodology and inputs outlined in Appendix B of the Distribution System Code (“Economic Evaluation”).

### 2.1.2.2.1 Offer to Connect – Content & Process

Based on the output of its Economic Evaluation, Toronto Hydro will set out in the Offer to Connect the following, as applicable:

(a) Whether the offer is a firm offer or an estimate of costs that would be revised in the final payment to reflect actual costs incurred;

(b) the amount of the capital contribution;

(c) the calculation used to determine the amount of the capital contribution including all of the assumptions and inputs used to produce the economic evaluation;

(d) a statement as to whether the offer includes work for which the Customer may obtain an alternative bid, and, if so, the process by which the Customer may obtain the alternative bid;

(e) a description of, and costs for, the work that is eligible for alternative bid and the work that is not eligible for alternative bid associated with the expansion broken down into the following categories:
   (i) labour (including design, engineering and construction);
   (ii) materials;
   (iii) equipment; and
   (iv) overhead costs (including administration);

(f) the amount for any Additional Alternative Bid Costs;

(g) the amount for the basic cost of connection; and

(h) the expansion deposit amount.

If there is a conflict between an Offer to Connect and these Conditions of Service, the Offer to Connect shall govern.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

2.1.2.2  Transfer Price for Work that is Eligible for Alternative Bid

The transfer price for the expansion work that is eligible for alternative bid shall be the lower of the cost to the Customer (“Customer’s Cost”) to construct the expansion facilities or the amount set out in the initial Offer to Connect to do the expansion work that is eligible for alternative bid. The Customer’s Cost shall mean:

(a) The costs the Customer paid to have the eligible alternative bid expansion work performed, as supported by evidence satisfactory to Toronto Hydro; and
(b) Any costs incurred by Toronto Hydro and charged to the Customer as a result of the Customer selecting to perform expansion work using an alternative bid.

For greater clarity, the cost referred to in (a) does not include any costs associated with completing connection work as identified in the Offer to Connect.

If the Customer does not provide the cost to construct the expansion facilities as referred to in (a), to Toronto Hydro within 30 days of the expansion facilities being energized, then the amount of the transfer price shall be the amount set out in the initial Offer to Connect to do expansion the work that is eligible for alternative bid.

Toronto Hydro will assume ownership of the facilities as of the date that the facilities were energized unless otherwise specified in the Offer to Connect.

2.1.2.2.3  Alternative Bid Final Economic Evaluation & Capital Contribution Settlement

If the Offer to Connect is a firm offer and the Customer has exercised the alternative bid option, Toronto Hydro will carry out a final Economic Evaluation once the expansion facilities are energized. The final Economic Evaluation will be based on the amounts used in the firm offer for costs and forecasted revenues, plus any transfer price to be paid to the Customer. If the required capital contribution amount from the final Economic Evaluation (“Final Capital Contribution”) differs from the required capital contribution amount from the initial Economic Evaluation (“Initial Capital Contribution”), the Customer will be responsible for the Final Capital Contribution and not the Initial Capital Contribution. Toronto Hydro and the Customer shall arrange to settle any amounts owing as necessary, including by way of set off.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Toronto Hydro will provide the Customer with the calculation used to determine the final capital contribution amount including all of the assumptions and inputs used to produce the final Economic Evaluation at no cost to the Customer.

2.1.2.3 Expansion Deposit

As noted above, an expansion to Toronto Hydro’s distribution system results in Expansion Costs and OM&A Costs. Given that the capital contribution that the Customer shall pay to Toronto Hydro may not fully offset these costs for Toronto Hydro, Toronto Hydro may require the Customer to provide an expansion deposit in addition to the capital contribution. The expansion deposit is intended to hold Toronto Hydro harmless with respect to the expansion.

For Class 3, 4, and 5 Customers an Offer to Connect may require the Customers to provide an expansion deposit to cover the difference between the costs associated with the expansion as outlined in Section 2.1.2 and the amount of the capital contribution paid by the Customer, in accordance with Toronto Hydro’s Economic Evaluation of the expansion.

Toronto Hydro will require the Customer to provide the expansion deposit, as contained in the Offer to Connect, prior to the commencement of any expansion work or the installation of any connection assets.

Where a Customer intends to exercise the alternative bid option, Toronto Hydro may require the Customer to post an expansion deposit in an amount equal to the costs for the expansion work that is ineligible for alternative bid (collectively the “Initial Expansion Deposit”), prior to the commencement of any expansion work or the installation of any connection assets. Once the expansion facilities are energized, and Toronto Hydro has conducted a final Economic Evaluation and determined a final capital contribution amount, Toronto Hydro may require the Customer to post an additional deposit to be added to the Initial Expansion Deposit such that the total expansion deposit, made up of the initial expansion deposit and the additional deposit (collectively the “Total Expansion Deposit”), is equal to the difference between the costs associated with the expansion as outlined in Section 2.1.2, including the transfer price, and the amount of the final capital contribution.

Toronto Hydro may retain or realize on any expansion deposit from the Customer for the purposes of covering any amounts that the Customer owes to Toronto Hydro pursuant to the Offer to Connect. These amounts may include an outstanding capital contribution, and the costs associated with completing,
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

repairing, or bringing up to standard the expansion facilities (e.g. bringing expansion facilities up to proper design and technical specifications; ensuring that facilities operate properly when energized).

In addition, for Customers that exercise the alternative bid option, Toronto Hydro may retain 10% of the Total Expansion Deposit, for a warranty period of up to two years and may apply such deposit to any work required to repair the expansion facilities within the two-year warranty period. At the end of the warranty period, Toronto Hydro shall return to the Customer the unused portion of the Total Expansion Deposit that was retained for the warranty period.

The two-year warranty period begins at the end of the Realization Period. The Realization Period for a project ends:

- For residential developments, upon the first to occur of the materialization of the last forecasted connection in the expansion project, or five (5) years after energization of the expansion facilities,
- For commercial and industrial developments, upon the first to occur of the materialization of the last forecasted demand, or five (5) years after energization of the expansion facilities, or
- For residential developments combined with commercial or industrial developments, upon the first to occur of the materialization of both the last forecasted connection and the last forecasted demand, or five (5) years after energization of the expansion facilities.

Any expansion deposit must be either in the form of (i) cash or (ii) an irrevocable commercial letter of credit issued by a Schedule I bank as defined in the Bank Act, or (iii) surety bond, but the form of deposit must expressly provide for its use to cover the events for which it is held as a deposit.

Except for the warranty portion of the Total Expansion Deposit which shall be retained for the duration of the warranty period, once the facilities are energized, Toronto Hydro shall reduce any expansion deposit amount at the end of each 365-day period as specified in the Offer to Connect.

The amount of the reduction at the end of each 365-day period is calculated by multiplying any expansion deposit by a percentage, less any portion that Toronto Hydro has retained or realized. The percentage is derived by dividing the actual connections (for residential developments) or actual demand (for commercial and industrial developments) completed or materialized in that 365-day period, incremental to any connections completed or demand that materialized in any previous 365-day period, by the total number of connections (for residential developments) or actual demand (for commercial and industrial developments) contemplated in the Offer to Connect. (For
example, if twenty percent of the forecasted connections or demand materialized in a year, and Toronto Hydro has not retained or realized any portion of any expansion deposit in accordance with the Offer to Connect, then Toronto Hydro will return to the Customer twenty percent of the expansion deposit.

However, if after five (5) years from the energization date of the expansion facilities the total number of connections (for residential developments) or the actual demand (for commercial and industrial developments) contemplated by the Offer to Connect have not materialized, Toronto Hydro shall retain any cash held as an expansion deposit, or be entitled to realize on any letter of credit or bond held as an expansion deposit and retain any cash resulting therefrom, with no obligation to return any portion of such monies to the Customer at any time.

If the Customer has provided any expansion deposit in the form of cash, any portion of any expansion deposit held as cash returned to the Customer shall include interest on the returned amount from the date of receipt of the full amount of the expansion deposit at the Prime Business Rate set by the Bank of Canada less 2 percent.

2.1.2.4 Supply Agreement

Class 3, 4 and 5 Customers may be required to enter into a Supply Agreement with Toronto Hydro to clarify the responsibilities of each party pertaining to the construction and maintenance of the expansion and or connection assets.

2.1.2.5 Rebates of Capital Contribution

As noted above, when a new Customer connection or the addition of new load necessitates an expansion to Toronto Hydro’s distribution system, Toronto Hydro conducts an economic evaluation. The economic evaluation considers costs associated with the expansion and forecasts revenues that the expansion will enable. If, within five (5) years of the energization of the expansion facilities, a subsequent Customer:

- connects new load to Toronto Hydro’s distribution system;
- derives a benefit from the expansion facilities;
- the new load had not been forecasted and not included in the economic evaluation; and
- the subsequent Customer is a Class 3, 4, or 5 Customer,

then the subsequent Customer (“Unforecasted Customer”) shall contribute a fair share of the cost that was incurred to construct the expansion. In such a case, Toronto Hydro shall collect the fair share from the Unforecasted
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Customer and shall provide that share as a rebate to the initial contributor (i.e. the Customer that initially paid the required capital contribution) to the expansion.

The amount of the fair share of the Unforecasted Customer, and therefore the amount of the rebate to the capital contribution of the initial contributor(s), will be determined by Toronto Hydro by apportioning the overall benefits associated with the expansion between the Unforecasted Customer and the initial (or previous) contributor(s). If applicable, Toronto Hydro may consider any or all of the following factors when apportioning the overall benefits:

(a) the relative name-plate rated capacity of the connections;
(b) the relative load levels;
(c) the line length that the Unforecasted Customer requires in comparison to the line length that the initial contributor(s) requires in the context of the expansion;
(d) the proportion of the five (5) year period of time after the energization date of the expansion that the Unforecasted Customer will be connected to the Toronto Hydro distribution system; and
(e) any other factor that Toronto Hydro, in its sole discretion, considers to be relevant to the determination.

2.1.2.6 Feeder Capacity Optimization

Toronto Hydro will provide service to the Customer during the Realization Period based upon the Estimated Incremental Demand indicated in the Offer to Connect that has been signed by the Customer. However, unused capacity will not be reserved past the Realization Period.

After the Realization Period Toronto Hydro reserves the right to examine the Customer’s peak demand with a view to optimizing its feeder capacity. If the actual peak demand is lower than the Estimated Incremental Demand, then Toronto Hydro will adjust downwards its internal peak demand forecast and may re-assign any unused capacity if it determines this is appropriate to meet other demand needs.

After the Realization Period the Customer shall obtain the consent of Toronto Hydro prior to effecting any substantial increase its peak demand, regardless of the Estimated Incremental Demand set forth in the Offer to Connect, or through past demand history.
2.1.3 Connection Denial

The DSC sets outs the conditions for a Distributor to deny connections. The DSC lists reasons for which a Building that "lies along" a distribution line may be refused connection to that line. This section should describe reasons why a distributor may not be obligated to connect the Customer and provide additional details, where relevant, about specific conditions that may result in a refused connection in accordance with the DSC code. For example, the criteria for establishing an unsafe connection or a connection, which adversely affects the system, should be further documented within the Conditions of Service.

The Distribution System Code provides for the ability of a Distributor to deny connections. Toronto Hydro is not obligated to connect a Customer within its service area if the connection would result in any of the following:

- Contravention of existing laws of Canada or the Province of Ontario, including the Ontario Electrical Safety Code
- Violations of conditions in Toronto Hydro’s Licence
- Use of a Toronto Hydro distribution system line for a purpose that it does not serve and that Toronto Hydro does not intend to serve
- Adverse affect on the reliability or safety of Toronto Hydro’s distribution system
- Public safety reasons or imposition of an unsafe work situation beyond normal risks inherent in the operation of Toronto Hydro’s distribution system
- A material decrease in the efficiency of the Toronto Hydro’s distribution system
- A materially adverse effect on the quality of distribution services received by an existing connection
- If the person requesting the connection owes Toronto Hydro money for distribution services
- Potential increases in monetary amounts that already are in arrears with Toronto Hydro
- If an electrical connection to Toronto Hydro’s distribution system does not meet Toronto Hydro’s design requirements
- Any other conditions documented in Toronto Hydro’s Conditions of Service.

If Toronto Hydro refuses to connect a Customer in its service area that lies along one of its distribution lines, Toronto Hydro shall inform the person requesting the connection of the reasons for the denial, and where Toronto Hydro is able to provide a remedy, make an Offer to Connect in accordance with Section 2.1.2 of these Conditions of Service. If Toronto Hydro is not capable of resolving the issue, it is the responsibility of the Customer to do so before a connection can be made.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

2.1.4 Inspections Before Connections

*In this section, the Distributor should state the requirement for inspection by the Electrical Safety Authority prior to the commencement of electricity supply.*

All Customer electrical installations shall be inspected and approved by the Electrical Safety Authority (ESA) and must also meet Toronto Hydro’s requirements. Toronto Hydro requires notification from the ESA of this approval prior to the energization of a Customer’s supply of electricity. Where a “Connection Authorization” from the ESA has been issued to Toronto Hydro, it is valid for the connection of a service for a period of up to six (6) months from the date of issue. If the connection of service has not been completed after six (6) months, a new “Connection Authorization” is required. Services that have been disconnected for a period of six (6) months or longer must also be re-inspected and approved by the ESA, prior to reconnection.

Temporary services, typically used for construction purposes and for a period of twelve months or less, must be inspected and approved by the ESA. The temporary service may be re-inspected by the ESA should the period of use exceed six (6) months.

Customer-Owned substations must be inspected by both the ESA and Toronto Hydro.

Transformer rooms shall be inspected and approved by Toronto Hydro prior to the installation of Toronto Hydro’s equipment.

Duct banks shall be inspected and approved by Toronto Hydro prior to the pouring of concrete and again before backfilling. A mandrel shall be used to clear all extraneous material from completed ducts and a site contractor shall perform this work in the presence of a Toronto Hydro inspector. A mandrel, approved by Toronto Hydro for a nominal diameter of duct, will be passed through each duct. In the event of ducts blocked by ice, the owner’s representative will be responsible for clearing the ducts prior to the cable installation. Connection to existing concrete duct banks or cable chamber shall be done only by a contractor approved by Toronto Hydro. All work done on existing Toronto Hydro’s plant must be authorized by Toronto Hydro and carried out in accordance with all applicable safety acts and regulations.

Provision for metering shall be inspected and approved by Toronto Hydro prior to energization.

2.1.5 Relocation of Plant

*This section should specify the distributor’s policy with respect to requests for relocation of plant and the conditions under which the requestor is or may be required to pay for the relocation of plant should be specified. Sharing arrangements also should be noted.*
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

When requested to relocate distribution plant, Toronto Hydro will exercise its rights and discharge its obligations in accordance with existing acts, by-laws and regulations including the Public Service Works on Highways Act, agreements, easements and law. In the absence of existing agreements, Toronto Hydro is not obligated to relocate the plant. However, Toronto Hydro shall resolve the issue in a fair and reasonable manner. Resolution in a fair and reasonable manner shall include consideration of the impact of the proposed relocation on the other Customers of Toronto Hydro. The response to the requesting party shall explain the feasibility or unfeasibility of the relocation and a fair and reasonable charge for relocation based on cost recovery principles.

The Customer shall contact Toronto Hydro prior to undertaking work that may result in an encroachment on Toronto Hydro plant.

If a Customer proposes to:

a) alter existing buildings, structures or apparatus; or
b) construct new buildings, structures or apparatus

that may result in an encroachment on the electrical and working clearances required by Toronto Hydro for the existing Toronto Hydro distribution plant, the Customer shall:

1) Notify Toronto Hydro and request that Toronto Hydro determine in a fair and reasonable manner whether the relocation of the existing distribution plant is acceptable;
2) If, in Toronto Hydro’s discretion a Coordination Agreement is required, enter into an agreement with Toronto Hydro to execute the relocation; and
3) Pay for the relocation costs incurred by Toronto Hydro to have the required Toronto Hydro distribution plant relocated, based on the Coordination Agreement, if applicable, or cost recovery principles.

If a Customer encroaches upon the electrical and working clearances set by Toronto Hydro, Toronto Hydro shall determine in a fair and reasonable manner whether the Customer shall be required to remove the encroachment at its own expense, or shall pay, based on cost recovery for work required, the costs incurred by Toronto Hydro to have the required distribution plant relocated.

Toronto Hydro may collect a Design Pre-payment from the Customer in order to initiate design activities in the preparation of a job-quotation for distribution plant relocation works. Upon acceptance of the job-quotation, the Design Pre-payment will be credited towards the Customer’s financial obligations for the relocation work. If the Customer does not accept Toronto Hydro’s job-quotation, or if the Customer
withdraws its application, or if Toronto Hydro is unable to provide a job-quote, then Toronto Hydro may refund the Design Pre-payment less any costs incurred by Toronto Hydro.

In the course of maintaining and enhancing Toronto Hydro's distribution plant, Toronto Hydro may need to relocate distribution plant that is owned by Toronto Hydro. Costs associated with such relocation(s) shall be borne by Toronto Hydro, except that, in accordance with Section 3.2(g) hereof, if the Customer requests that such maintenance or construction activities be done outside Toronto Hydro's normal working hours, the Customer may be required to pay for any incremental costs incurred by Toronto Hydro as a result thereof.

2.1.6 Easements

In this section, any requirements for easements should be described.

To maintain the reliability, integrity and efficiency of the distribution system, Toronto Hydro has the right to have supply facilities on private property and to have easements registered against title to the property. Easements are required where facilities serve property other than property where the facilities are located and/or where Toronto Hydro deems it necessary.

The Customer will prepare at its own cost any required reference plan to the satisfaction of Toronto Hydro. Easement documents are prepared by the Toronto Hydro Legal Services Department. Four copies of the deposited reference plan must be supplied to Toronto Hydro prior to the preparation of the easement documents. Details will be provided upon application for service.

2.1.7 Contracts

This section should outline the types of contracts that are available for each type of Customer, including standard, implied and special contracts. Connection agreements and operating agreements should be listed and referenced as appendices to the Conditions of Service, if applicable.

2.1.7.1 Contract for New or Modified Electricity Service

Toronto Hydro shall only connect a Customer for a new or modified supply of electricity upon receipt by Toronto Hydro of the following:

- a completed and signed contract for service in a form acceptable to Toronto Hydro;
- payment to Toronto Hydro of any applicable connection fee;
- an inspection and approval by the Electrical Safety Authority of the electrical equipment for the new service; and
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

- a Connection Agreement as requested or required pursuant to Section 2.1.7.4.

2.1.7.2  Implied Contract

In all cases, notwithstanding the absence of a written contract, Toronto Hydro has an implied contract with any Customer that is connected to Toronto Hydro’s distribution system and receives distribution services from Toronto Hydro. The terms of the implied contract are embedded in Toronto Hydro’s Conditions of Service, the Rate Handbook, Toronto Hydro’s rate schedules, Toronto Hydro’s licence, the Distribution System Code, the Standard Supply Service Code and the Retail Settlement Code, all as amended from time to time.

The acceptance of supply of electricity or related services from Toronto Hydro constitutes a binding contract with Toronto Hydro, which includes these Conditions of Service and all terms thereunder. The person so accepting the supply of electricity or related services shall be liable for payment for same, and such contract shall be binding upon such person’s heirs, administrators, executors, successors or assigns.

2.1.7.3  Special Contracts

Special contracts that are customized in accordance with the service requested by the Customer normally include, but are not necessarily limited to, the following examples:

- construction sites
- mobile facilities
- non-permanent structures
- special occasions, etc.
- embedded generation facilities

2.1.7.4  Connection Agreements

Toronto Hydro may require a Customer to enter into a Connection Agreement in a form acceptable to Toronto Hydro. Until such time as the Customer executes such a Connection Agreement with Toronto Hydro, the Customer shall be deemed to have accepted and agreed to be bound by all of the terms in the Connection Agreement attached to this as Schedule A in Section 6.

A Generator, and a Wholesale Market Participant shall enter into a Connection Agreement as per Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

An Embedded Distributor shall enter into a Connection Agreement in a form acceptable to Toronto Hydro. Until such time as the Embedded Distributor executes such a Connection Agreement with Toronto Hydro, the Embedded Distributor shall be deemed to have accepted and agreed to be bound by all of the terms in these Conditions of Service that apply to such Embedded Distributor.

Toronto Hydro shall make a good faith effort to enter into a Connection Agreement with a distributor connected to Toronto Hydro’s distribution system in accordance with the requirements in the Distribution System Code issued by the Ontario Energy Board.

If there is a conflict between a Connection Agreement with a Customer, Generator, Wholesale Market Participant or Embedded Distributor and this Conditions of Service, the Connection Agreement shall govern.

2.1.7.5 Payment by Building Owner

The owner of a Building is responsible for paying for the supply of electricity by Toronto Hydro to the owner’s Building except for any supply of electricity to the Building by Toronto Hydro in accordance with a request for electricity by an occupant(s) of the Building.

A Building owner wishing to terminate the supply of electricity to its Building must notify Toronto Hydro in writing. Until Toronto Hydro receives such written notice from the Building owner or its authorized representative, the Building owner and/or the occupant(s), as applicable, shall be responsible for payment to Toronto Hydro for the supply of electricity to such Building. Toronto Hydro may refuse to terminate the supply of electricity to an owner’s Building when there are occupant(s) in the Building (i.e. during certain periods of the winter).

Effective April 1, 2011, after closure of an account opened pursuant to a request, directly or indirectly, from an occupant of the property other than the owner or its authorized representative, Toronto Hydro shall not seek to recover any charges for service provided to a rental unit in a residential complex or residential property from the owner of the residential complex or residential property, unless the owner has agreed to assume responsibility for those charges. An owner, either personally or through an authorized representative, may enter into an agreement with Toronto Hydro whereby the owner agrees to assume responsibility for paying for continued service to the rental unit after closure of an occupant account. Where the owner has not agreed to assume responsibility for charges for continued service, Toronto Hydro may disconnect the service without notice. Toronto Hydro will not be responsible for any
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

liabilities or damages, which may occur as a result of the service being disconnected.

Where a non-residential property has been vacated by an occupant of the property, and Toronto Hydro has not been notified that a new occupant should be billed for the electricity supplied to the property and the owner has not submitted a written request to disconnect the electricity supply, Toronto Hydro will bill the owner for the electricity supply to the property until such time as Toronto Hydro is notified by the owner or a new occupant that the occupant should be billed for the electricity supply.

2.1.7.6 Opening and Closing of Accounts

A Consumer who wishes to open or close an account for the supply of electricity by Toronto Hydro shall contact Toronto Hydro’s Call Centre by phone, by written request (including requests submitted by facsimile), through Toronto Hydro’s web site, or other means acceptable to Toronto Hydro.

The Consumer shall be responsible for payment to Toronto Hydro for the supply of electricity to the property up to the date Toronto Hydro is notified of the termination of the account.

2.2 Disconnection

*In this section, the Distributor should specify under what circumstances it has the right or obligation to disconnect a Customer. This section also should outline the business processes used by the distributor, including notification and timing provisions.*

Toronto Hydro reserves the right to disconnect service for reasons not limited to:

- Contravention of the laws of Canada or the Province of Ontario, including the Ontario’s Electrical Safety Code.
- A material adverse effect on the reliability and safety of Toronto Hydro’s distribution system.
- Imposition of an unsafe worker situation beyond normal risks inherent in the operation of Toronto Hydro’s distribution system.
- A material decrease in the efficiency of Toronto Hydro’s distribution system.
- A materially adverse effect on the quality of distribution services received by an existing connection.
- Inability of Toronto Hydro to perform planned inspections and maintenance.
- Failure of the Consumer or Customer to comply with a directive of Toronto Hydro that Toronto Hydro makes for purposes of meeting its licence obligations.
- Overdue amounts payable to Toronto Hydro including the non-payment of a security deposit.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

- Electrical disturbance propagation caused by Customer equipment that is not corrected in a timely fashion.
- Any other conditions identified in these Conditions of Service.

Toronto Hydro may disconnect the supply of electricity without notice in accordance with the following conditions, and as stated in Sections 2.1.7.5 and 2.2.2 in these Conditions of Service:

- pursuant to a court order;
- for emergency or safety reasons;
- for system reliability reasons;
- a Customer intentionally avoids bill payments by applying or re-applying for a new account under a different account-holder name, or otherwise acts fraudulently;
- a Customer who has been disconnected has self-reconnected; or
- pursuant to an order of the Electrical Safety Authority.

A Customer intending to demolish any buildings that house Toronto Hydro’s distribution equipment shall notify Toronto Hydro at least four (4) months in advance of demolition. The Customer shall pay Toronto Hydro for the costs of removing all electrical equipment owned by Toronto Hydro that is located on private property. Provided the Customer has made all necessary arrangements, Toronto Hydro shall remove all its equipment by the date agreed to with the Customer.

2.2.1 Disconnection & Reconnection – Process and Charges

Immediately following the due date, steps will be taken to collect the full amount of the electricity bill. If the bill is still unpaid sixteen calendar days after the due date and ten calendar days after a disconnect notice has been delivered to the Customer, the service may be disconnected and not restored, or a Timed Load Interrupter Device may be installed, until payment arrangements satisfactory to Toronto Hydro have been made, including any costs of reconnection. Such discontinuance or restriction of service does not relieve the Customer of the liability for arrears or other applicable charges for the balance of the term of contract, nor shall Toronto Hydro be liable for any damage to the Customer’s premises resulting from such discontinuance or restriction of service, other than physical damage to facilities arising directly from entry on the Customer’s property. Disconnect notices will be in writing and if given by mail shall be deemed to be received on the third business day after mailing.

Notwithstanding the foregoing, Toronto Hydro shall not shut off the supply of electricity to a property for non-payment as set forth above during such periods as may be prescribed by regulations under the Electricity Act, 1998. Upon discovery that a hazardous condition or disturbance propagation (feedback) exists, Toronto Hydro will notify the Customer to rectify the condition at once. If the Customer fails to
make satisfactory arrangements to remedy the condition within seven calendar days after a disconnect notice has been given to the Customer, the service may be disconnected and not restored until satisfactory arrangements to remedy the condition have been made. Toronto Hydro shall not be liable for any damage to the Customer’s premises resulting from such discontinuance of service, except for physical damage to facilities arising directly from Toronto Hydro’s entry on the Customer’s property. Disconnect notices will be in writing and if given by mail shall be deemed to be received on the third business day after mailing.

Notwithstanding the above, in the case of a residential Customer that has provided Toronto Hydro with documentation from a physician confirming that disconnection poses a risk of significant adverse effects on the physical health of the Customer or on the physical health of the Customer’s spouse, or dependent family member or other person that regularly resides with the Customer, shall not be disconnected for non-payment until 60 days from the date on which the disconnection notice is delivered.

At the request of a residential Customer, Toronto Hydro shall send a copy of any disconnection notice issued to the Customer for non-payment to a third party designated by the Customer for that purpose provided that the request is made no later than the last day of the applicable minimum notice period. As well, residential Customers may at any time prior to disconnection, designate a third party to also receive any future notice of disconnection.

Upon receipt of a connection termination request by the Customer, Toronto Hydro will disconnect and/or remove Toronto Hydro’s connection assets at the Customer’s cost as outlined in Table 2 in Section 5 of these Conditions of Service.

When a Customer requests a disconnection and a reconnection of its supply of electricity then the Customer shall pay a fair and reasonable charge based on cost recovery principles or pay the applicable fees in accordance with the charges presented in the Standard Service Charges listing, as available on Toronto Hydro’s website.

Prior to working near Toronto Hydro's overhead conductors, Customers shall contact Toronto Hydro to determine if a disconnection of electricity is required. Toronto Hydro will provide a disconnection and reconnection for a fee as outlined above.

Where Toronto Hydro installs a Timed Load Interrupter Device or disconnects a Customer for non-payment, Toronto Hydro will provide to the Customer (i) the Fire Safety Notice of the Office of the Fire Marshal; (ii) any other public safety notices or information bulletins issued by public safety authorities and provided to Toronto Hydro, which provide information to consumers respecting dangers associated with the disconnection of electricity service, and when applicable, (iii) written notice to
the Customer explaining the effect of a Timed Load Interrupter Device on service, along with a telephone number for the Customer to obtain further information.

Where a Timed Load Interrupter Device is installed or a service is disconnected by Toronto Hydro for non-payment, Toronto Hydro will remove the Timed Load Interrupter Device or reconnect the service within 2 business days of the outstanding account balance being paid in full or the Customer entering into an arrears payment agreement. A Customer may request the continued use of the Timed Load Interrupter Device during the course of the arrears payment agreement.

2.2.2 Unauthorized Energy Use

Notwithstanding the provisions of Section 2.1.7.2 (Implied Contract) and Section 2.1.7.5 (Payment by Building Owner), Toronto Hydro reserves the right to disconnect the supply of electricity to a building or property where the building or property has, or appears to have, been used for unlawful purposes, including energy diversion or theft of power. The supply of electricity to the building or property may not be reconnected for the existing Customer until Toronto Hydro receives full payment from the existing customer of all reasonable costs and losses incurred by Toronto Hydro arising from the unauthorized energy use, including costs of inspections, repair costs, commodity costs, disconnection costs, and reconnection costs. If other than the existing customer requests reconnection, Toronto Hydro may recover any reconnection charges approved by the Ontario Energy Board.

2.3 Conveyance of Electricity

2.3.1 Limitations on the Guaranty of Supply

In this section, the Distributor should specify its limitations on the guaranty of supply. The Distributor also should reference the provisions for “Powers of Entry” described in section 40 of the Electricity Act, 1998.

Toronto Hydro will endeavour to use reasonable diligence in providing a regular and uninterrupted supply of electricity but does not guarantee a constant supply or the maintenance of unvaried frequency or voltage and will not be liable in damages to the Consumer or Customer by reason of any failure in respect thereof.

Consumers or Customers requiring a higher degree of security than that of normal electricity supply are responsible to provide their own back-up or standby facilities. Consumers or Customers may require special protective equipment at their premises to minimize the effect of momentary power interruptions.

Customers requiring a three-phase supply should install protective apparatus to avoid damage to their equipment, which may be caused by the interruption of one phase, or non-simultaneous switching of phases of Toronto Hydro’s electricity supply.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

During an emergency, Toronto Hydro may interrupt supply to a Consumer in response to a shortage of supply of electricity, or to effect repairs on its distribution system, or while repairs are being made to Consumer or Customer-Owned equipment. Toronto Hydro shall have rights to access property in accordance with Section 40 of the Electricity Act, 1998 and any successor acts thereto.

To assist with distribution system outages or emergency response, Toronto Hydro may require a Consumer or Customer to provide Toronto Hydro with emergency access to Consumer or Customer-Owned distribution equipment that normally is operated by Toronto Hydro or Toronto Hydro-Owned equipment on Consumer’s property.

2.3.2 Power Quality

This section should outline the guidelines and policies to which the Distributor will endeavor to adhere to in conveying electricity supply, such as service voltage guidelines and outage notification processes. This section also should indicate the process the distributor uses for handling voltage disturbances and power quality testing and remedial action.

This section also should include conditions under which supply of electricity to Customers may be interrupted. Additionally, conditions under which the supply may become unreliable or intermittent should be described.

2.3.2.1 Power Quality Testing

Where a Consumer or Customer provides evidence or data indicating that a power quality or an electromagnetic interference (EMI) problem may be originating from Toronto Hydro’s distribution system, Toronto Hydro will investigate the issue within a reasonable timeframe in an attempt to identify the underlying cause. Depending on the circumstances, this may include a review of relevant power interruption data, trend analysis, and power quality monitoring. The power quality monitoring will be initially conducted at the main revenue meter and may be expanded to the Customer’s facility if warranted.

Toronto Hydro will recommend and/or take appropriate mitigation measures upon determination that the cause resulting in the power quality concern:

1. originates from the Toronto Hydro distribution system;
2. is deemed a system delivery issue; and
3. industry standards are not met.

If Toronto Hydro is unable to correct the problem without adversely affecting other Toronto Hydro Consumers, Customers, or the distribution system, then it is not obligated to make the corrections. Toronto Hydro will apply appropriate
industry standards and good utility practice as a guideline. If the problem lies on the Customer side of the demarcation point, Toronto Hydro may seek reimbursement from the Customer for the costs incurred in the investigation.

2.3.2.2 Prevention of Distortion on the Distribution System

Customers having a non-linear load shall implement the necessary corrective measures such as installing proper filters and/or improving their grounding connections. The Customer’s configuration of their electrical equipment must comply with the latest edition of IEEE Standard 519.

The Consumer or Customer should be aware that some distribution system events such as, but not limited to, capacitor switching may cause problems with highly sensitive equipment, and the Consumer or Customer shall be responsible for mitigating these effects.

2.3.2.2.1 Voltage Distortion

The Customer shall install equipment that is designed such that the voltage harmonic distortion contribution complies with Table 1 – Voltage distortion limits, of the latest edition of IEEE Standard 519. Specifically, the limit on individual harmonic distortion should be maintained at or below 3%, while the limit on total harmonic distortion should be maintained at or below 5%.

2.3.2.2.2 Current Distortion

The Customer shall install equipment that is designed such that the current harmonic distortion limits are not exceeded, and shall remain in compliance with Table 2 – Current distortion limits for systems rated 120 V through 69 kV, of the latest edition of IEEE Standard 519.

2.3.2.3 Obligation to Help in the Investigation

If Toronto Hydro has reason to believe the Customer’s equipment is the source causing unacceptable harmonics or voltage level on Toronto Hydro’s distribution system, the Customer shall help Toronto Hydro by providing required equipment information, relevant data and necessary access for monitoring the equipment.

The Customer shall assist in the investigation and resolution of power quality problems by:

(a) maintaining and providing Toronto Hydro with a detailed log of exact times and dates of poor power quality;
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

(b) ensuring corrective measures such as filters and/or grounding are installed for non-linear loads connected to the distribution system;
(c) assisting Toronto Hydro in determining whether the Customer’s equipment may be a source of undesirable system disturbances; and
(d) ceasing operation of the equipment deemed to be the cause of system disturbances until satisfactory remedial action has been taken.

If requested, Toronto Hydro can provide a list of recommended vendors that are qualified to perform an independent investigation, and to supply and install corrective equipment at the Customer’s facility. All independent investigations or any requirements for corrective equipment shall be at the Customer’s sole responsibility and expense.

2.3.2.4 Timely Correction of Deficiencies

If an undesirable system disturbance is being caused by the Customer's equipment, the Customer will be required to cease operation of the equipment until remedial action has been taken by the Customer, at the Customer’s expense. If the Customer does not take such action within a reasonable time, Toronto Hydro shall disconnect the supply of electricity to the property, in order to mitigate any adverse effects on other Customers or Consumers.

2.3.2.5 Notification for Interruptions

Although it is Toronto Hydro’s policy to minimize inconvenience to Consumers, it is necessary to occasionally interrupt a Consumer's supply of electricity to allow work on Toronto Hydro’s electrical system. Toronto Hydro will endeavor to provide such Consumers with reasonable notice of planned power interruptions. However, interruption times may change due to inclement weather or other unforeseen circumstances. Toronto Hydro shall not be liable in any manner to such Consumers for failure to provide such notice of planned power interruptions or for any change to the schedule for planned power interruptions.

During an emergency, Toronto Hydro may interrupt supply of electricity to a property without notice in response to a shortage of supply of electricity or to effect repairs on Toronto Hydro’s distribution system or while repairs are being made to Customer-Owned equipment, or to conduct work of an emergency nature involving the possibility of injury to persons or damage to property or equipment.
2.3.2.6 Notification to Consumers on Life Support

Consumers who require an uninterrupted source of power for life support equipment must provide their own equipment for these purposes. Consumers with life support system are encouraged to inform Toronto Hydro of their medical needs and their available backup power. These Consumers are responsible for ensuring that the information they provide Toronto Hydro is accurate and up-to-date.

With planned interruptions, the same procedure as prescribed in Section 2.3.2.5 will be observed. For those unplanned power interruptions that extend beyond two hours and the time expected to restore power is longer than what was indicated by Consumers (registered on life support) as their available backup power, Toronto Hydro will endeavor to contact these Consumers but will not be liable in any manner to the Consumers for failure to do so.

2.3.2.7 Emergency Interruptions for Safety

Toronto Hydro will endeavour to notify Consumers prior to interrupting the supply of electricity. However, if an unsafe or hazardous condition is found to exist, or if the use of electricity by apparatus, appliances, or other equipment is found to be unsafe or potentially damaging to Toronto Hydro or the public, the supply of electricity may be interrupted without notice.

2.3.2.8 Emergency Service (Trouble Calls)

Toronto Hydro will exercise reasonable diligence and care to deliver a continuous supply of electricity to the Consumer. However, Toronto Hydro cannot guarantee a supply that is free from interruption.

When power is interrupted, the Consumer should first ensure that failure is not due to blowing of fuses within the installation. If there is a partial power failure, the Consumer should obtain the services of an electrical contractor to carry out necessary repairs. If, on examination, it appears that Toronto Hydro’s main source of supply has failed, the Consumer should report these conditions at once to Toronto Hydro’s Call Centre by calling 416-542-8000.

Toronto Hydro operates a Call Centre 24 hours a day to provide emergency service to Consumers. Toronto Hydro will initiate restoration efforts as rapidly as practicable.

2.3.2.9 Outage Reporting

Depending on the outage, duration and the number of Consumers affected, Corporate Communications of Toronto Hydro may issue a news release to
advise the general public of the outage. In turn, news radio stations may call for information on a 24-hour basis when they hear of an outage.

2.3.3 Electrical Disturbances

This section should outline the guidelines to which the Distributor and the Customer will be expected to adhere to regarding electrical disturbances.

Toronto Hydro shall not be held liable for the failure to maintain supply voltages within standard levels due to Force Majeure as defined in Section 2.3.5 of these Conditions of Service.

Voltage fluctuations and other disturbances can cause flickering of lights and other serious difficulties for Consumers connected to Toronto Hydro’s distribution system. Customers must ensure that their equipment does not cause disturbances such as harmonics and spikes that might interfere with the operation of adjacent Consumer equipment. Equipment that may cause disturbances includes large motors, welders and variable speed drives, etc. In planning the installation of such equipment, the Customer must consult with Toronto Hydro.

Some types of electronic equipment, such as video display terminals, can be affected by the close proximity of high electrical currents that may be present in transformer rooms. Toronto Hydro will assist in attempting to resolve any such difficulties at the Customer’s expense.

Consumers who may require an uninterrupted source of power supply or a supply completely free from fluctuation and disturbance must provide their own power conditioning equipment for these purposes.

2.3.4 Standard Voltage Offerings

This section should specify the voltages that the distributor may provide to each type of Customer, based on their supply requirements. This section should include both the primary and secondary voltages that are available. Additionally, any physical or geographic constraints on a particular voltage, or conditions under which voltages may not be provided should be detailed in this section.

2.3.4.1 Primary Voltage

The primary voltage to be used will be determined by Toronto Hydro for both Toronto Hydro-Owned and Customer-Owned transformation. Depending on the voltage of the plant that “lies along”, the preferred primary voltage will be at 27.6/16 kV grounded wye, three phase, four-wire system. However, in the downtown core of the City of Toronto the primary voltage will be 13.8/8 kV grounded wye, three phase, four wire; or 13.8 kV three phase, three wire, depending on the area.
2.3.4.2 Supply Voltage

Toronto Hydro’s preferred secondary voltage is:

- 120/240 V, single phase, and
- 120/208 V or 347/600 V, three phase.

Depending on the system availability in the area, 120/208 V two phase, three wire may be supplied in place of 120/240 V.

The supply voltage governs the limit of supply capacity for any Customer.

When supply is from secondary street circuits the demand load shall be as follows:

(i) residential: if at 120/240 V, single phase or 120/208 V, two phase, three wire, then up to 200 A service size;

residential: if at 120/240 V, single phase or 120/208 V, two phase, three wire, then a 400 A service size feeding from the overhead distribution system must be connected directly to transformation via underground supply arrangement;

commercial: if at 120/240 V, single phase or 120/208 V, two phase, three wire, then up to 75 kVA demand load;

(ii) if at 347/600 V, three phase, four wire, then up to 80 kVA demand load;

(iii) if at both 120/240 V, single phase and 347/600 V, three phase, four wire, then up to 100 kVA sum total demand load; or

(iv) if at 120/208 V, three phase, four wire, then up to 100 kVA demand load.

For supply exceeding the above capacity, the Customer is required to provide a transformer, pad mounted or in a building vault, on private property, to receive supply of electricity up to the following capacities:
When a pad-mounted transformer is used the demand load shall be as follows:

(i) if fed from 4.16/2.4 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 300 kVA demand load;

(ii) if fed from 13.8/8 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 750 kVA demand load; or

(iii) if fed from 27.6/16 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 750 kVA and 1500 kVA demand load respectively.

When a transformer vault is used:

(i) if fed from 4.16/2.4 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 300 kVA demand load;

(ii) if fed from 13.8/8 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 1,500 kVA and 2,500 kVA demand load respectively depending on system availability in the area, (i.e. three phase);

(iii) if fed from 27.6/16 kV primary at 120/208 V or 347/600 V, three phase, four wire, then supply is available for loads up to 1,500 kVA and 2,500 kVA demand load respectively (i.e. three phase); or

(iv) if fed from 347/600 V network system, then supply is available for loads up to 10,000 kVA demand load depending on system availability in the area (i.e. three phase).

When the Customer requires voltages other than at the available supply voltage, or demands by a single occupant exceed the limits indicated above, the Customer shall consult with Toronto Hydro. Toronto Hydro may advise the Customer of any special conditions and requirements to obtain such non-standard services. However, Toronto Hydro is under no obligations to provide any non-standard services.

When a Customer is required to provide transformation facilities on private property in accordance with this section, and the Customer is unable to do so or is severely constrained from doing so, the Customer may request Toronto Hydro to provide the transformation facilities from Toronto Hydro’s existing
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

underground distribution system. If requested by the Customer, and if Toronto Hydro determines in its sole discretion that it is able to do so, then Toronto Hydro may provide these transformation facilities. By requesting this option, the Customer agrees to pay Toronto Hydro a fee for providing the transformation facilities as part of the Customer’s connection costs, in addition to any associated expansion costs.

2.3.4.3 Multiple Connections to Main Distribution System

Customers will be generally connected to one point of the main Toronto Hydro distribution system. Toronto Hydro may offer a second point of connection to another point of the main Toronto Hydro distribution system when:

a) the Customer is fed by the 13.8 kV underground radial system as defined in Section 1.1.1; or
b) the Customer’s point load exceeds the maximum set in Section 2.3.4.2 for service from a transformer vault.

For Customers supplied from the 13.8 kV underground radial system, if the demand exceeds the limit set for transformer vaults as set out in Section 2.3.4.2 the Customer may be eligible for the service depicted in Sketch 1(H-1) in Section 6, Reference #4 “Toronto Hydro Requirements for the Design and Construction of Customer-Owned High Voltage Substations”.

Where multiple connections exist, and unless otherwise agreed by Toronto Hydro, load should be distributed evenly across all active connections. Load must not be transferred from one active connection to another without the permission of Toronto Hydro.

Toronto Hydro will determine the location of any connection points to its main distribution system. Although Toronto Hydro will give consideration to arguments relating to a need for diversity of supply, it retains the right to determine in its sole discretion, not to allow a second point of connection to another part of the main distribution system.

2.3.5 Voltage Guidelines

This section should specify what voltages the distributor’s Customers can reasonably expect, with reference to CSA Standard CAN3-235 current edition.

Toronto Hydro maintains service voltage at the Customer's service entrance within the voltage variation limits shown in the table below:
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Voltage Variation Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extreme Operating Conditions</td>
</tr>
<tr>
<td>Single Phase</td>
<td></td>
</tr>
<tr>
<td>120/240</td>
<td>106/212</td>
</tr>
<tr>
<td>Two Phase 3 Wire</td>
<td></td>
</tr>
<tr>
<td>120/208</td>
<td>110/190</td>
</tr>
<tr>
<td>Three Phase 4 Wire</td>
<td></td>
</tr>
<tr>
<td>120/208Y</td>
<td>220/380</td>
</tr>
<tr>
<td>240/416Y (*)</td>
<td>306/530</td>
</tr>
<tr>
<td>347/600Y</td>
<td>306/530</td>
</tr>
</tbody>
</table>

(*) 240/416Y is no longer a standard voltage offered by Toronto Hydro.

The Voltage Variation Limits, with the exception of the limits for Two Phase 3 Wire 120/208, are based on C.S.A. Standard CAN3-C235-83. Where voltages lie outside the indicated limits for Normal Operating Conditions but within the indicated limits for Extreme Operating Conditions as noted above, improvement or corrective action will be taken by Toronto Hydro on a planned or programmed basis, but not necessarily on an emergency basis. Where voltages lie outside the indicated limits for Extreme Operating Conditions, improvement or corrective action may be taken on an emergency basis depending on a number of factors, which include, but are not limited to, the location and nature of load or circuit, the extent to which voltage limits are exceeded, and the duration of time for which the limits have been exceeded.

Toronto Hydro shall practice reasonable diligence in maintaining voltage levels, but is not responsible for variations in voltage related to external factors. External factors include, but are not limited to, those factors that necessitate operating contingencies, and exceptionally high loads and low voltage supply from the transmitter or host distributor. Toronto Hydro shall not be liable for any delay or failure in the performance of any of its obligations under these Conditions of Service due to any events or causes beyond the reasonable control of Toronto Hydro, including, without limitation, severe weather, flood, fire, lightning, other forces of nature, acts of animals, epidemic, quarantine restriction, war, sabotage, act of a public enemy, earthquake, insurrection, riot, civil disturbance, strike, restraint by court order or public authority, or action or non-action by or inability to obtain authorization or approval from any governmental authority, or any combination of these causes (“Force Majeure”).

2.3.6 Emergency Backup Generation Facilities

Distributors should include the following statements in this section:

- Customers with portable or permanently connected emergency generation capability shall comply with all applicable criteria of the Ontario Electrical Safety
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Code and in particular, shall ensure that Customer emergency generation does not back feed into the Distributor’s system.

- Customers with permanently connected emergency generation equipment shall notify their Distributor regarding the presence of such equipment.

Any other requirements the Distributor imposes on Customers with emergency backup generation facilities should be described in this section.

Emergency backup generation is installed by Customers for backup of load when utility power supply is not available. A Customer with portable or permanently connected emergency backup generation shall comply with all applicable criteria of the Ontario Electrical Safety Code (OESC) and in particular, shall ensure that its Emergency Backup Generation Facility does not back feed into the Distributor’s system or back feed through the revenue meter.

A Customer with an Emergency Backup Generation Facility in Open-Transition mode shall further ensure that its facility does not parallel with, nor adversely affect Toronto Hydro’s distribution system.

Customers who consider installing a Closed-Transition switch shall notify Toronto Hydro and shall submit documentation that satisfies Toronto Hydro’s technical requirements. Customers shall obtain written authorization from Toronto Hydro prior to commissioning the switch in Closed-Transition mode. Closed-Transition switches must not operate the generator in parallel with Toronto Hydro’s distribution system for longer than 100 ms under any circumstances. Further requirements are specified in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”, Section 3.2 Emergency Backup Generation Technical Requirements.

For parallel generation refer to Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.

Customers with a permanently connected Emergency Backup Generation Facility operating in parallel shall notify Toronto Hydro regarding the presence of such equipment and shall enter into a connection agreement as required in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.

For portable emergency backup generation, residential Customers can install a Toronto Hydro approved meter base plug-in transfer device onto a 200 A, 4-jaw meter socket that is installed outdoors. All installations must meet Toronto Hydro approval requirements and will only be considered for residential Customers with 120/240 V, single-phase and up to a 200 A service. Customers must initially contact Toronto Hydro to begin the installation process for the meter base plug-in transfer device. Following a Toronto Hydro field visit at the Customer’s residence to determine the feasibility of the installation, the Customer will be advised whether to proceed to make arrangements to have the meter base plug-in transfer device installed.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

by an electrical contractor that is licensed by the Electrical Safety Authority. In addition, during the time of installation or removal of the meter base plug-in transfer device, a service disconnection/reconnection and breaking/sealing of the revenue meter will be required and shall be performed by Toronto Hydro. The Customer shall enter into a connection agreement and pay for associated Toronto Hydro costs.

The installation of a meter base plug-in transfer device is not permitted where a Customer location has a distributed generation installation (i.e. Micro Feed-in Tariff, Feed-in Tariff, Net Metering, Load Displacement, and Renewable Energy Standard Offer Program).

2.3.7 Metering

This section should specify the options available to a Customer for metering equipment. The Distributor also should outline the technical requirements for meter installations including location and associated main switch.

Toronto Hydro will supply, install, own, and maintain all meters, instrument transformers, ancillary devices, and secondary wiring that are required for revenue metering.

For further metering conditions and requirements refer to the three reference documents as specified in Section 6, Reference #6 “Toronto Hydro Metering Requirements 750 Volts or Less”, Reference #7 “Toronto Hydro Metering Requirements for 13.8 kV & 27.6 kV Customer-Owned Substations”, and Reference #9 “Toronto Hydro Metering Services and Charges”.

A generation facility on the Toronto Hydro distribution system shall follow the metering requirements and conditions as specified in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.

2.3.7.1 General

Describe the Distributor’s access to meter installation requirements here.

Toronto Hydro will typically install metering equipment at the Customer supply voltage. The Customer must provide a convenient and safe location, satisfactory to Toronto Hydro, for the installation of meters, wires and ancillary equipment. Meters for new or upgraded residential services will be mounted outdoors on an approved meter socket as specified in Section 6, Reference #6 – “Toronto Hydro Metering Requirements 750 Volts or Less” Table I.

No person, except those authorized by Toronto Hydro, may remove, connect, or otherwise interfere with meters, wires, or ancillary equipment owned by Toronto Hydro.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

The Customer will be responsible for the care and safekeeping of Toronto Hydro meters, wires and ancillary equipment on the Customer’s premises. If any Toronto Hydro equipment installed on Customer premises is damaged, destroyed, or lost other than by ordinary wear and tear, tempest or lightning, the Customer will be liable to pay to Toronto Hydro the value of such equipment, or at the option of Toronto Hydro, the cost of repairing the equipment.

The location allocated by the property owner for Toronto Hydro metering shall provide direct access for Toronto Hydro staff and shall be subject to satisfactory environmental conditions, some of which are:

- Maintain a safe and adequate working space in front of equipment, not less than 1.2 metres (48") and a minimum ceiling height of 2.1 metres (84”);
- Maintain an unobstructed working space in front of equipment, free from, or protected against, the adverse effects of moving machinery, vibration, dust, moisture or fumes; and
- Meter sockets installed outdoors shall be located outside a 1.0 metres radius from the discharge of a combustible gas relief device or vent. Where the 1.0 metres clearance cannot be achieved, the Customer shall contact the gas company to install a certified overpressure cut-off type regulator, which only requires 0.3 metres clearance from the meter socket.

Where Toronto Hydro deems self-contained meters to be in a hazardous location, the Customer shall provide a meter cabinet or protective housing.

Any compartments, cabinets, boxes, sockets, or other workspace provided for the installation of Toronto Hydro’s metering equipment shall be for the exclusive use of Toronto Hydro. No equipment, other than that provided and installed by Toronto Hydro, may be installed in any part of the Toronto Hydro metering workspace.

2.3.7.1.1 Metering Requirements for Multi-Unit Residential Rental Buildings and Condominiums

Developers of new multi-unit residential rental buildings and new and existing condominiums (collectively, “MURBs”), or boards of directors of condominiums, or authorized persons in charge of any other applicable class of unit under Ontario Regulation 389/10, may choose to have Toronto Hydro install unit smart metering, or to have Toronto Hydro install a bulk interval meter for the purpose of enabling unit sub-metering by a licensed unit sub-meter provider.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Installation of Unit Smart Metering by Toronto Hydro

Upon the request of a MURB developer or a condominium board of directors, Toronto Hydro will install unit smart metering that meets the functional specification of Ontario Regulation 425/06 – *Criteria and Requirements for Meters and Metering Equipment, Systems and Technology* (smart metering). In that case, each separate residential and commercial unit, as well as common areas, will become direct individual customers of Toronto Hydro, with the common area accounts held by the developer, condominium corporation or the landlord as the case may be.

The MURB developer or condominium board of directors may choose an Alternative Bid for the installation of unit smart metering. In that case, the MURB developer, landlord or condominium board of directors is required to:

(i) select and hire a qualified contractor;
(ii) ensure all work that is eligible for alternative bid is done in accordance with Toronto Hydro’s technical standards and specifications; and
(iii) assume full responsibility for the installation and warranty all aspects for a period of 2 years from date of commissioning.

Where the MURB developer or condominium board of directors transfers the metering facilities installed under the alternative bid option to Toronto Hydro, and provided Toronto Hydro has inspected and approved the facilities installed, Toronto Hydro shall pay the condominium corporation, landlord or developer a transfer price. The transfer price shall be the lower of the cost to the MURB developer or condominium board of directors to install the metering facilities or Toronto Hydro’s fully allocated cost to install the metering facilities.

Common Area Metering

Where units in a MURB are to be unit smart metered, the responsible party (MURB developer, condominium board of directors, or landlord) shall enter into a contract with Toronto Hydro for the supply of electrical energy for all common or shared services. Common or shared services typically include lighting of all common areas shared by the tenants, or unit owners, and common services such as heating, air conditioning, water heating, elevators, and common laundry facilities. In such cases, consumption for all common areas will be separately metered.
Installation of Bulk Interval Metering by Toronto Hydro

Where bulk interval metering is supplied by Toronto Hydro to an exempt distributor for the purpose of enabling unit sub-metering, the responsible party (i.e., the developer, condominium corporation, or landlord, but not the unit sub-meter provider) shall enter into a contract with Toronto Hydro for the supply of electrical energy to the building.

2.3.7.1.2 Main Switch and Meter Mounting Devices

The Customer's main switch immediately preceding the meter shall be installed so that the top of the switch is no higher than 1.83 m and that the bottom of the switch is no lower than 1.0 m from the finished floor and shall permit the sealing and padlocking of:

(a) the handle in the "open" position; and
(b) the cover or door in the closed position.

Meter mounting devices for use on Commercial/Industrial accounts shall be installed on the load side of the Customer's main switch and be located indoor.

The Customer is required to supply and install a Canadian Standards Association (CSA) approved meter socket for the use of Toronto Hydro’s self-contained socket meters for the main switch ratings and supply voltages listed in Table 5 in Section 5 of these Conditions of Service.

The Customer is required to supply and install a meter cabinet to contain Toronto Hydro’s metering equipment for the main switch ratings and supply voltages listed in Table 6 in Section 5 of these Conditions of Service.

Meter centers installed for individual metering applications must meet the requirements specified in Table 8 in Section 5 of these Conditions of Service.

The Customer shall permanently and legibly identify each metered service with respect to its specific address, including unit or apartment number. The identification shall be applied to all service switches, circuit breakers, meter cabinets, and meter mounting devices.

2.3.7.1.3 Service Mains Limitations

The metering provision and arrangement for service mains in excess of either 600 A or 600 V shall be submitted to Toronto Hydro for approval before building construction begins. Additional standards and
requirements for services metered above 600 V can be made available upon request.

2.3.7.1.4 Special Enclosures

Specially constructed meter entrance enclosures will be permitted for outdoor use upon Toronto Hydro’s approval of a written application for use.

2.3.7.1.5 Meter Cables

The Customer shall provide meter loops having a length of 610 mm in addition to the length between line and load entry points. Line and load entry points shall be approved by Toronto Hydro prior to installation. Where more than two conductors per phase are used, the connectors shall be provided by the Customer (see Table 6 in Section 5 of these Conditions of Service for required cabinets). Mineral insulated, solid or hard drawn wire conductors are not acceptable for meter loops. Any variation from the above must first be checked and approved by Toronto Hydro prior to installation.

2.3.7.1.6 Barriers

Barriers are required in each section of switchgear or service entrance equipment between metered and unmetered conductors and/or between sections reserved for Toronto Hydro use and sections for Customer use.

2.3.7.1.7 Doors

Side-hinged doors shall be installed over all live electrical equipment where Toronto Hydro personnel may be required to work (i.e. line splitters, unmetered sections of switchgear, breakers, switches, metering compartments, meter cabinets and enclosures). These hinged doors shall have provision for sealing and padlocking. Where bolts are used, they shall be of the captive knurled type. All outer-hinged doors shall open no less than 135°. All inner-hinged doors shall open to a full 90°.

2.3.7.1.8 Auxiliary Connections

All connections to circuits such as fire alarms, exit lights and Customer instrumentation shall be made to the load side of Toronto Hydro’s metering. No Customer equipment shall be connected to any part of the Toronto Hydro metering circuit.
2.3.7.1.9 Working Space

Clear working space shall be maintained in front of all equipment and from all side panels in accordance with the Ontario Electrical Safety Code.

2.3.7.2 Current Transformer Boxes

Where current transformers are required, the Distributor should outline the technical requirements to be followed for such installations.

Where instrument transformers are incorporated in low voltage switchgear, the size of the chamber and number of instrument transformers shall be as shown in Table 7 in Section 5 of these Conditions of Service. A separate meter cabinet must be supplied and installed by the Customer, located to the satisfaction of Toronto Hydro and as close as possible to the instrument transformer compartment.

The cabinet and the compartment will be connected by an empty 1½ inch conduit, the length of which shall not exceed 30 m, and which shall include a maximum of three 90° bends. The conduit will be provided for the exclusive use of Toronto Hydro. No fittings with removable covers are permitted.

The meter cabinet shall be grounded by a minimum #6 copper grounding conductor, not installed in the above conduit. The Customer shall install a strong nylon or polyrope pull line in the conduit, with an excess of 1500 mm loop left at each end.

The final layout and arrangements of components must be approved by Toronto Hydro prior to fabrication of equipment.

Where two or more circuits are totalized, or where remote totalizing is involved, or where instrument transformers are incorporated in high voltage switchgear (greater than 750 V), Toronto Hydro will issue specific metering requirements.

2.3.7.3 Interval Metering

Where interval metering is required or requested, the Distributor should outline the technical requirements to be followed for such installations. Included with the technical specifications should be the conditions under which interval metering will be supplied.

Interval meters will be installed for all new or upgraded services where the peak demand is forecast to be 50 kW or greater, or for any Customer wishing to participate in the spot market pass-through pricing. Prior to the installation of an
interval meter, the Customer must provide and install a 32 mm (1 ¼ in) conduit from the meter cabinet to an outdoor location for the installation of an antenna to be mounted 1.8 m (6 ft) above ground. The conduit installation shall not be more than 30.5 m (100 ft) in length.

If Toronto Hydro determines in its sole discretion that a cellular installation is not feasible, Toronto Hydro may require the Customer to install a 13 mm (1/2 in) conduit from the meter cabinet to the telephone room. Toronto Hydro will arrange for the installation of a telephone line, terminated in the meter cabinet for the exclusive use of Toronto Hydro to retrieve interval meter data. The Customer will be responsible for the installation of the telephone infrastructure (conduit, cable, and jack). The phone line will be Toronto Hydro-Owned, direct dial, voice quality, active 24 hours per day, and energized prior to meter installation.

2.3.7.4 Meter Reading

This section should outline the requirements for access to meters for the purposes of obtaining readings and the process to be used if a reading is not obtained.

The Customer or Consumer must provide or arrange free, safe and unobstructed access during regular business hours to any authorized representative of Toronto Hydro for the purpose of meter reading, meter changing, or meter inspection. Where premises are closed during Toronto Hydro’s normal business hours, the Customer or Consumer must, on reasonable notice, arrange such access at a mutually convenient time.

2.3.7.5 Final Meter Reading

This section should outline any requirements associated with obtaining a final meter reading on termination of a contract for service.

When a service is no longer required, the Customer or Consumer shall provide sufficient notice of the date the service is to be discontinued so that Toronto Hydro can obtain a final meter reading as close as possible to the final reading date. The Customer or Consumer shall provide access to Toronto Hydro or its agents for this purpose. If a final meter reading is not obtained, the Consumer shall pay a sum based on an estimated demand and/or energy for electricity used since the last meter reading, as determined by Toronto Hydro.

2.3.7.6 Faulty Registration of Meters

In this section, the Distributor should outline the process for dealing with metering errors.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Metering electricity usage for the purpose of billing is governed by the federal *Electricity and Gas Inspection Act* and associated regulations, under the jurisdiction of Measurement Canada, Industry Canada. Toronto Hydro’s revenue meters are required to comply with the accuracy specifications established by the regulations under the above Act.

In the event of incorrect electricity usage registration, Toronto Hydro will determine the correction factors based on the specific cause of the metering error and the Consumer’s electricity usage history. The Consumer shall pay for all the electricity supplied a reasonable sum based on the reading of any meter formerly or subsequently installed on the premises by Toronto Hydro, due regard being given to any change in the characteristics of the installation and/or the demand. If Measurement Canada, Industry Canada determines that the Consumer was overcharged, Toronto Hydro will reimburse the Consumer for the amount incorrectly billed.

If the incorrect measurement is due to reasons other than the accuracy of the meter, such as incorrect meter connection, incorrect connection of auxiliary metering equipment, or incorrect meter multiplier used in the bill calculation, the billing correction will apply for the duration of the error. Toronto Hydro will correct the bills for that period in accordance with the regulations under the *Electricity and Gas Inspection Act*.

2.3.7.7 Meter Dispute Testing

_This section should outline the process by which a Customer can dispute a meter measurement or read and seek redress._

Metering inaccuracy is an extremely rare occurrence. Most billing inquiries can be resolved between the Customer or Consumer and Toronto Hydro without resorting to the meter dispute test.

Either Toronto Hydro or the Customer or Consumer may request the service of Measurement Canada to resolve a dispute. If the Customer or Consumer initiates the dispute, Toronto Hydro will charge the Customer or Consumer a meter dispute fee if the meter is found to be accurate and Measurement Canada rules in favor of the utility.

2.4 Tariffs and Charges

2.4.1 Service Connection

_The Distributor should outline the rates that have been established for providing the Customer with a connection to the electrical distribution system and all services_
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

provided by the Distributor as per the rules and regulations laid out by all applicable codes.

Charges for distribution services are made as set out in the Schedule of Rates available from Toronto Hydro. Notice of Rate revisions shall be published in major local newspapers. Information about changes will also be mailed to all Consumers with the first billing issued at revised rates.

2.4.1.1 Customers Switching to Retailer

There are no physical service connection differences between Standard Service Supply (SSS) customers and third party retailers’ customers. The supply of electricity to both types of customers is delivered through Toronto Hydro’s distribution system with the same distribution requirements. Therefore, all service connection requirements applicable to the SSS customers are applicable to third party retailers’ customers.

2.4.2 Energy Supply

This section should outline the process the Distributor has established for the following:

- Provision of Standard Service Supply to the Customer, per the rules and regulations laid out in the Retail Settlement Code and the Standard Service Supply Code.
- Provision of Supply to the Customer through a Retailer, per the rules and regulations laid out in the Retail Settlement Code.
- Wheeling of energy and all associated tariffs.

2.4.2.1 Standard Service Supply (SSS)

All Toronto Hydro Consumers are Standard Service Supply (SSS) Consumers until Toronto Hydro is informed by the Consumer or the Consumer’s authorized retailers of their switch to a competitive electricity supplier. The Service Transfer Request (STR) must be made by the Consumer or the Consumer’s authorized retailer.

2.4.2.2 Retailer Supply

Consumers transferring from Standard Service Supply (SSS) to a retailer shall comply with the Service Transfer Request (STR) requirements as outlined in Sections 10.5 through 10.5.6 of the Retail Settlement Code. All requests shall be submitted as electronic file and transmitted through EBT Express. Service Transfer Request (STR) shall contain information as set out in Section 10.3 of the Retail Settlement Code.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

If the information is incomplete, Toronto Hydro shall notify the retailer or Consumer about the specific deficiencies and await a reply before proceeding to process the transfer.

2.4.2.3 Wheeling of Energy

All Customers or Consumers considering delivery of electricity through the Toronto Hydro distribution system are required to contact Toronto Hydro for technical requirements and applicable tariffs.

2.4.3 Deposits

*This section should outline any deposit and prudential requirements the Distributor has established for providing a Customer with Distribution Services, supply through Standard Service Supply or through a Retailer, per the rules and regulations laid out in the Distribution System Code.*

Whenever required by Toronto Hydro, including, but not limited to, as a condition of supplying or continuing to supply Distribution Services, Consumers and Customers shall provide and maintain security in an amount that Toronto Hydro deems necessary and reasonable. Toronto Hydro will not discriminate among Customers with similar risk profiles or risk related factors except where expressly permitted under the Distribution System Code.

Except for Consumers or Customers who meet the security deposit waiver conditions described below, all Consumers or Customers are required to provide an account security deposit to Toronto Hydro, which, at the Consumer’s or Customer’s election, must be in the form of (i) cash, cheque or Money Order, or, if approved by Toronto Hydro, Visa or MasterCard or (ii) for non-residential Consumers or Customers an automatically renewing irrevocable commercial letter of credit from a bank defined in the *Bank Act, 1991*, c.46. Toronto Hydro will not accept third party guarantees.

The amount of the account security deposit will be based on the billing factor times the estimated average bill during the most recent 12 months. The billing factor is 2.5 for monthly billed Consumers or Customers.

Where there is no established historical electricity consumption information for the service premises, the deposit will be based on a reasonable estimate using information from a like property used for similar purposes.

Where the Consumer or Customer, other than a residential electricity Customer, has more than one disconnection notice in a relevant 12 month period, the highest bill in the period will be used for the calculation of the deposit.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

If requested by the Consumer or Customer, Consumers or Customers will be permitted to pay the security deposit in equal installments over a maximum of 4 months, or over a period of 6 months for residential Customers (including where a new security deposit is required due to Toronto Hydro having to apply the existing security deposit against amounts owing).

The security deposit may be waived based on the following criteria:

a) The Consumer or Customer has a good payment history based on the most recent customer history with some portion in the most recent 24 months, during which time the Consumer or Customer:
   - had no more than one (1) notice of disconnection; AND
   - had no more than one (1) payment returned for insufficient funds (“NSF”); AND
   - had no disconnect/collection trip; AND
   - had no security deposit applied for amounts owing.

The minimum time period for good payment history is as follows:

   - Residential - 1 year
   - Non-residential <50 kW demand rate class - 5 years
   - All other classes - 7 years

or

b) The Consumer or Customer provides a letter from another electricity or gas distributor in Canada confirming good payment history. The letter must contain information consistent with the good payment criteria described in this document.

or

b) The Consumer or Customer (other than those in a >5000 kW demand rate class) provides a satisfactory credit check at its expense. The acceptable Equifax Credit scores are as follows:

   - Residential - Consumer Score of 700 or greater
   - Business - Commercial Score of 20 or lower

or

d) Residential account deposits may be waived where the Consumer or Customer enrolls in the Toronto Hydro’s pre-authorized payment plan and supplies at least two pieces of identification information, provided that a deposit will be required if the pre-authorized payment plan is cancelled.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

e) The Customer is a bulk-metered residential condominium as defined in the Condominium Act, 1998 and has provided Toronto Hydro with a signed declaration attesting to their legal status as a residential condominium corporation.

or

f) The residential Customer has been qualified as an “eligible low-income customer” and requests a waiver.

The credit history of a separate legal entity or a company that carries on business under a different business name cannot be used to provide a non-residential Customer with a security deposit waiver irrespective of common ownership or affiliation. Toronto Hydro reserves the right to deny a security deposit waiver request at its sole discretion.

The security deposit may be reduced for non-residential Consumers or Customers with 50 kW or greater demand, based on the following criteria:

Where the Consumer or Customer has a credit rating from a recognized credit rating agency, (Dominion Bond Rating Service, Standard & Poor’s or Moody’s) the maximum amount of deposit required will be reduced as follows:

<table>
<thead>
<tr>
<th>Credit Rating</th>
<th>Allowable Reduction</th>
</tr>
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<tbody>
<tr>
<td>AAA- and above</td>
<td>100%</td>
</tr>
<tr>
<td>AA-, AA, AA+</td>
<td>95%</td>
</tr>
<tr>
<td>A-, From A, A+ to below AA</td>
<td>85%</td>
</tr>
<tr>
<td>BBB-, From BBB, BBB+ to below A</td>
<td>75%</td>
</tr>
<tr>
<td>Below BBB-</td>
<td>0%</td>
</tr>
</tbody>
</table>

Equivalent ratings from other bond rating agencies would apply for the same reductions.

In the above case, the commodity price used to calculate the deposit shall be the same as the price used by the IESO for the purpose of determining maximum net exposures and prudential support obligations for market participants other than distributors, low-volume Consumers and designated Consumers.

Interest will accrue monthly on security deposits commencing when the total deposit has been received. The rate shall be at the average Chartered Bank Prime Rate as published on the Bank of Canada Web site, less 2%. The interest rate shall be updated by Toronto Hydro at a minimum on a quarterly basis. The interest will be calculated and applied to the existing deposit prior to each update and at a minimum on a yearly basis.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Toronto Hydro will undertake an annual review of all security deposit requirements for each Consumer or Customer based on the *Good Payment History* described in this document.

- Where it is determined that all or part of the deposit is no longer required, the account will be credited with the amount of the deposit plus accumulated interest.

- Where it is determined that a deposit is now required or needs to be adjusted upward, the amount of the deposit will be added to the next regular bill and is payable by the due date of that bill, except for residential Customers which they shall be permitted to pay the adjusted amount in equal installments paid over a period of at least 6 months. As with all outstanding balances payment arrangements that are satisfactory to Toronto Hydro may be made.

- For Consumers or Customers in the >5000 kW demand rate class, where the Consumer or Customer is in a position to have some or all of the deposit refunded, only 50% of the deposit will be returned. A higher refund requires a credit rating from a recognized credit rating agency based on the criteria previously stated.

*Note: Where no deposit is on file or there is a deposit that does not meet the maximum amount, and the Consumer or Customer meets the good payment history criteria but does not meet the time frame, a new or increased deposit amount will not be added.*

Upon closure of the Consumer’s or Customer’s account with Toronto Hydro, including a Consumer or Customer move from standard supply service (“SSS”) to a competitive retailer where the retailer is performing the billing function (retailer consolidated billing), for all accounts types, the balance of the security deposit plus accumulated interest, after all amounts owing are paid, will be returned to the Consumer or Customer within six weeks of the closure of the account.

No earlier than 12 months after the payment of a security deposit or the making of a prior demand for a review, a Consumer or Customer may request in writing that the deposit amount be reviewed to determine whether the entire amount of the security deposit, or some portion of it, should be returned to the Consumer or Customer as it is no longer required.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

2.4.4 Billing

This section should outline the billing methods and billing cycles the Distributor has established to provide a Customer with Distribution Services, supply through Standard Service Supply or through a Retailer, per the rules and regulations laid out in the Retail Settlement Code.

Toronto Hydro renders bills to its Customers on a monthly basis. Bills for the use of electrical energy may be based on either a metered or an unmetered connection.

Customers that are metered will be billed based on an actual meter reading. During periods when an actual meter reading is unavailable, Customers will be billed in accordance with the validating, estimating, and editing (VEE) process as described in Section 5.3 of the DSC.

Totalization of individually metered accounts is not allowed. However, a building that is Toronto Hydro unit smart metered may have an option of totalized billing for the common element meters in that building only.

The Customer may dispute charges shown on the Customer’s bill or other matters by contacting and advising Toronto Hydro of the reason for the dispute. Toronto Hydro will promptly investigate all disputes and advise the Customer of the results.

2.4.5 Payments and Overdue Account Interest Charges

This section should outline payment methods that the Distributor has established to provide the Customer with Distribution Services, supply through Standard Service Supply or through a Retailer as per the rules and regulations laid out in the Retail Settlements Code.

Toronto Hydro accepts payments in the form of a cheque (either mailed or delivered to a Toronto Hydro drop box), and through most financial institutions (either directly or through Pre-Authorized Payments).

Payment plans are available to Customers as per Section 2.6.2 of the Standard Supply Service Code. Except where the Customer is in arrears on payment to Toronto Hydro for electricity charges and has not entered into an arrears payment agreement with Toronto Hydro, an equal monthly payment plan option, whereby an equalized payment amount is automatically withdrawn from a Customer’s account with a financial institution on a monthly basis, is available for qualifying residential Customers. Except where the Customer is in arrears on payment to Toronto Hydro for electricity charges and has not entered into an arrears payment agreement with Toronto Hydro, an equal monthly billing plan option, whereby a monthly bill is issued to a Customer and the amount due in each bill is equalized over the course of a year, is available to Eligible Low-Income Customers.

Bills are payable in full by the due date; otherwise, overdue interest charges will
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

apply at a rate of 1.5% monthly (compounded) or 19.56% annually. Where a partial payment has been made by the Customer on or before the due date, the interest charge will apply only to the amount of the bill outstanding at the due date. The Customer will be required to pay additional charges for the processing of non-sufficient fund (N.S.F.) cheques.

Outstanding bills are subject to the collection process and may ultimately lead to the service being discontinued. Service will be restored once satisfactory payment and/or payment arrangements have been made (refer to Section 2.2.1).

2.4.6 Credit Refunds to Customer

When the Customer closes an account for any reason, it is the Customer’s responsibility to immediately notify Toronto Hydro of the termination of the account and to provide updated contact information including mailing address.

If a credit amount is left on the Customer’s account after Toronto Hydro issues a final bill, Toronto Hydro will mail a refund cheque to the Customer at the last known address on file.

2.5 Customer Information

The Conditions of Service shall describe the provision of information with respect to chapter 11 of the Retail Settlement Code. This specifies the rights of Consumers and retailers to access current and historical usage information and related data and the obligations of distributors in providing access to such information. The Conditions of Service should include reference to include information subject to privacy regulations and load profile information.

Any processes for handling requests for information outside of the requirements of the Retail Settlement Code should be described in this section.

Toronto Hydro’s Privacy Policy Statement describes how and why Toronto Hydro collects, uses, discloses, handles, and protects the personal information of its Customers, Consumers or members of the public. It also addresses the reasons why personal information is collected, used, or disclosed, how the information is safeguarded, and outlines individuals’ rights with respect to this information. Toronto Hydro’s Privacy Policy Statement can be found on its website.

A third party who is not a retailer may request historical usage information with the written authorization of the Consumer to provide their historical usage information.

Toronto Hydro will provide information appropriate for operational purposes that has been aggregated sufficiently, such that an individual’s Consumer information cannot reasonably be identified, at no charge to another distributor, a transmitter, the IESO or the OEB. Toronto Hydro may charge a fee that has been approved by the OEB for all other requests for aggregated information.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

At the request of a Consumer, Toronto Hydro will provide a list of retailers who have Service Agreements in effect within its distribution service area. The list will inform the Consumer that an alternative retailer does not have to be chosen in order to ensure that the Consumer receives electricity and the terms of service that are available under Standard Supply Service.

Upon receiving an inquiry from a Consumer connected to its distribution system, Toronto Hydro will either respond to the inquiry if it deals with its own distribution services or provide the Consumer with contact information for the entity responsible for the item of inquiry, in accordance with chapter 7 of the Retail Settlement Code.

An embedded distributor that receives electricity from Toronto Hydro shall provide load forecasts or any other information related to the embedded distributor’s system load to Toronto Hydro, as determined and required by Toronto Hydro. A distributor shall not require any information from another distributor unless it is required for the safe and reliable operation of either distributor’s distribution system or to meet a distributor’s licence obligations.

2.6 Temporary Services

A temporary service is a planned service connection requiring the supply of electricity typically for a period of less than twelve (12) months, after which the temporary service will be disconnected and removed. A temporary service is normally a metered service and is generally provided for construction purposes or special events.

Temporary services can be supplied overhead or underground. The Customer shall contact and provide specified information to Toronto Hydro in the early planning stages, so that Toronto Hydro can determine at its sole discretion the type of temporary service installation and the point of supply. The Customer is responsible for supplying, installing, and removing the required Customer’s temporary facilities on their property in accordance with Toronto Hydro requirements, and the Ontario Electrical Safety Code and Bulletins. There may be situations where the Customer is required to provide temporary transformation facilities on Customer’s private property.

The Customer is responsible for Toronto Hydro’s costs associated with the installation and removal of equipment required for the temporary service. The Customer shall pay in accordance with the Standard Service Charges specified on Toronto Hydro’s website. Where Standard Service Charges do not apply, the Customer shall pay a fair and reasonable charge based on cost recovery principles. In all cases, Toronto Hydro shall determine, at its sole discretion, the amount that the Customer shall pay.
Section 2 – DISTRIBUTION ACTIVITIES (GENERAL)

Subject to the requirements of Toronto Hydro, supply will be connected after receipt of a “Connection Authorization” from the Electrical Safety Authority (ESA), an account opened and payment for connection costs is received from the Customer.

A temporary service is generally provided for a period of no more than twelve (12) months, and the equipment for such temporary service may be re-inspected by the ESA at the end of a six (6) month period. The Customer shall inform Toronto Hydro if the temporary service extends beyond twelve (12) months.

Where a temporary service is to be provided, the Customer shall provide and maintain a designated area for posting Toronto Hydro information. The Customer is responsible for ensuring that the posted information is not tampered with or obstructed in any way. The entire site relating to where the temporary service is to be installed, which includes the route to and from all work areas, must be maintained at all times in accordance with all laws and regulations and in a safe condition which allows Toronto Hydro employees and representatives to carry out all work in a safe environment. The Customer shall be responsible for all damages and related costs sustained by any Toronto Hydro employee or representative in carrying out such work.

In addition to ESA requirements, where Toronto Hydro’s point of supply terminates at a pole or post the Customer shall leave 760 mm of cable at the masthead for connection purposes, and for:

a) a temporary secondary service connection up to 200 A at 120/240 V, 120/208 V or 347/600V, the supply connection shall terminate at a temporary pole that is installed by the Customer on Customer’s private property. The supply connection can be fed either from the overhead or underground distribution system. The Customer is responsible for installing all the necessary apparatus (e.g. conduit, meter socket, service equipment in weatherproof enclosure) on the pole.

b) overhead transformation feeding a temporary secondary service connection requiring electricity for a 400 A or 600 A service at 347/600 V, Toronto Hydro shall install temporary service conductors directly from the transformer secondary terminals and terminate at a temporary pole that is installed by the Customer on Customer’s private property. The Customer is responsible for installing all the necessary components (e.g. clevis, masthead, conduit) on the pole. The Customer shall extend the temporary service conductors from the pole to a housing where the main service entrance equipment and meter socket are to be installed.

In the case of temporary underground primary services, Toronto Hydro will install and connect temporary primary service cables to a temporary point of supply indicated by Toronto Hydro. The Customer shall be responsible for the installation of any civil infrastructure on Customer’s private property, and may be responsible for the installation and removal of the temporary electrical equipment as applicable.
3 CUSTOMER CLASS SPECIFIC

The Customer Class Specific section shall contain references to services and requirements, which are specific to individual Customer classes. This section should cover such items as:

- Demarcation Point.
- Metering.
- Service Entrance Requirements.
- Delineation of Ownership and Operational Points of Demarcation.
- Special Contracts.
- Other conditions specific to Customer class.

The following are examples of Customer specific subsections. It is recognized that Customer Classifications are unique to each Distributor. The Distributor is not limited by these examples to the range and scope of their Customer Classifications. Each Distributor therefore should review their current Classifications and ensure that all of their existing Customer Classifications are adequately covered by the Distributor’s Conditions of Service document.

3.1 Residential

Include all items that apply specifically to Residential Customers not covered under the General section.

Refer to Tables 1.1, 1.2 and 1.3 and Table 2 under Section 5 of these Conditions of Service for Point of Demarcation, Standard Allowance and Connection Fees for Residential Services.

3.1.1 Overhead Services

3.1.1.1 Minimum Requirements

In addition to, or in instances of deviation from the requirements of the Ontario Electrical Safety Code (latest edition), the following conditions shall apply:

(i) A clevis type insulator is to be supplied and installed by the Customer.

(ii) This point of attachment device must be located:

(a) Not less than 4.5 m nor greater than 5.5 m above grade (to facilitate proper ladder handling techniques). Building must have a minimum offset from property line of 1.2 m.

(b) Between 150 mm and 300 mm below the service head.

(c) Within 1 m of the face of the building.
(iii) Clearance (under maximum sag conditions of the conductors) must be provided between utility service conductors and finished grade of at least 4.7 m over lands accessible to vehicles and 3.7 m over or alongside walkways or areas unlikely travelled by vehicles.

A minimum horizontal clearance (under maximum swing conditions of the conductors) of 1 m must be provided from utility service conductors so that they cannot be reached by a person: (1) standing on a readily accessible surface such as a balcony, stairway, or fire escape, or (2) reaching from a window or door. Alternatively, a minimum vertical clearance (under maximum sag conditions of the conductors) of 2.5 m must be provided from utility conductors passing over a readily accessible surface such as a balcony, stairway, or fire escape.

(iv) A 4 jaw approved meter socket as specified in Section 6, Reference #6 – “Toronto Hydro Metering Requirements 750 Volts or Less” Table I shall be provided. Certain areas will require a 5-jaw socket as determined by Toronto Hydro. The Customer should contact Toronto Hydro to confirm details.

(v) Clear unobstructed access must be maintained to and in front of the meter location.

(vi) Service locations requiring access to adjacent properties (mutual drives, narrow side set-backs, etc.) will require the completion of an easement or written consent from the property owner(s) involved.

Proposed new or service changes in areas with mutual access (such as driveways, walkways) require:

- at least 50% ownership of the walkway or driveway by the property owner requesting the service when the width of the mutual property is less than 2 m. (Right of way access is not considered ownership);
- a minimum of 1 m width (for meter only installation) and a minimum 1.5 m width (for overhead connection access);
- absence of fences or other property separation;
- unobstructed access to service; and
- customer responsibility for disclosure of all property encumbrances.

Toronto Hydro assumes no liability for any property or meter location disputes between owner(s).
Section 3 – CUSTOMER CLASS SPECIFIC

(vii) The approved meter socket shall be mounted directly below the service mast such that the midpoint of the meter is 1.7 m (± 100 mm) above finished grade within 1 m of the face of the building (in front of any existing or proposed fence) that is closest to the Toronto Hydro source of supply, unless otherwise approved by Toronto Hydro.

3.1.1.2 Services Over Swimming Pools

Although the Ontario Electrical Safety Code allows electrical conductors to be located at adequate height, Toronto Hydro will not allow electrical conductors to be located above swimming pools.

Where a new swimming pool is to be installed it will be necessary to relocate, at the property owner's expense, any electrical conductors located directly over the proposed pool location.

Where overhead service conductors are in place over an existing swimming pool, Toronto Hydro will provide up to 30 metres of overhead service conductors, at no charge, to allow rerouting of the service. The property owner will pay any other costs.

3.1.2 Underground Services for Individual Residences

Customers requesting an underground service in an overhead area will be required to pay 100% connection costs for the underground service less the Standard Allowance for an overhead service.

The owner shall pay for any necessary road crossings.

The trench route must be approved by Toronto Hydro and is to follow the route indicated on the underground drawing supplied by Toronto Hydro. Any deviation from this route must be approved by Toronto Hydro. The Customer will be responsible for Toronto Hydro’s costs associated with re-design and inspection services due to changes or deviations initiated by the Customer or its agents.

The owner will assure the provision for the service entrance and meter meets Toronto Hydro approval.

Where there are other services to be installed (e.g. gas, telephone, and cable) these shall be coordinated to avoid conflict with Toronto Hydro’s underground cables. Toronto Hydro’s installation will not normally commence until all other servicing and grading have been completed.
Section 3 – CUSTOMER CLASS SPECIFIC

It is the responsibility of the owner or his/her contractor to obtain clearances from all of the utility companies (including Toronto Hydro) before digging.

It is the responsibility of the owner to contact Toronto Hydro to inspect each trench prior to the installation of Toronto Hydro’s service cables.

The owner shall provide unimpeded access for Toronto Hydro to install the service.

The owner shall ensure that any intended tree planting has appropriate clearance from underground electrical plant.

3.2 General Service

Include all items that apply specifically to general service Customers not covered under the other sections, and broken down (by load demand).

a) The Customer shall supply the following to Toronto Hydro well in advance of installation commencement:

- Required in-service date
- Proposed Service Entrance equipment’s Rated Capacity (Amperes) and Voltage rating and metering requirements
- Propose Total Load details in kVA and/or kW (Winter and Summer)
- Locations of other services, gas, telephone, water and cable TV.
- Details respecting heating equipment, air-conditioners, motor starting current limitation and any appliances which demand a high consumption of electricity
- Survey plan and site plan indicating the proposed location of the service entrance equipment with respect to public rights-of-way and lot lines.
- For General Service (50 – 999 kW and 1000 kW and above) Class Customers, electrical, architectural and/or mechanical drawings as required by Toronto Hydro.

b) The Customer shall construct and install all civil infrastructure (including but not limited to poles, UG conduits, cable chambers, cable pull rooms, transformer room/vault/pad) on private property, that is deemed required by Toronto Hydro as part of its connection assets. All such civil infrastructures are to be in accordance with Toronto Hydro’s current standards, practices, specifications and these Conditions of Service and are subject to Toronto Hydro’s inspection and acceptance.

Should the Customer construct and install the civil infrastructure related to connection assets, Toronto Hydro shall not include the associated civil component in its calculation of Basic and Variable Connection Fees.
Section 3 – CUSTOMER CLASS SPECIFIC

c) Alternatively, the Customer may have Toronto Hydro construct and install the civil infrastructure that forms part of Toronto Hydro’s connection assets on private property and the Customer will therefore be responsible for all costs via Basic Connection and Variable connection Fees (as applicable).

d) Toronto Hydro is responsible for the maintenance and repairs of its connection assets but not the transformer room(s) or any other civil structure that is part of the Customer’s building.

e) When effecting changes the Customer shall maintain sufficient clearances between electrical equipment and buildings and other permanent structures to meet the requirements of the Ontario Electrical Safety Code and the Occupational Health & Safety Act and Regulations.

f) It is the responsibility of the owner or his/her contractor to obtain clearances from all of the utility companies (including Toronto Hydro) before digging.

g) Provided the existing civil infrastructure has been maintained in satisfactory conditions by the Customer, Toronto Hydro will undertake the necessary programs to enhance its distribution plant at its expense, as part of its planned activities during normal business hours, Monday to Friday.

When a Customer requests that such planned or maintenance activities which may include an electricity disconnection be done outside Toronto Hydro’s normal business hours, then the Customer may be required to pay the incremental costs incurred by Toronto Hydro as a result thereof.

In the event that services or facilities to a Customer need to be restored as a result of these construction or maintenance activities by Toronto Hydro, they will be restored to an equivalent condition.

In addition, Toronto Hydro will carry out the necessary construction and electrical work to maintain existing supplies by providing standard overhead or underground supply services to Customers affected by Toronto Hydro’s construction activities. If a Customer requests special construction beyond the normal Toronto Hydro standard installation in accordance with the program, the Customer shall pay the additional cost associated therewith, including engineering and administration fees.

h) Toronto Hydro shall install, maintain, and replace, at its own cost, all those civil infrastructures that are part of its main distribution system (i.e. not including connection assets) that may be located on private property and which serve Customers that are located outside of that private property. These Toronto Hydro civil infrastructures will require an easement.
Section 3 – CUSTOMER CLASS SPECIFIC

i) The Customer shall install, maintain, and replace, at its own cost, all those civil infrastructures located on private property that are required to house the connection assets (i.e. the electrical equipment owned by Toronto Hydro) that serve Customers that are located on that private property.

Where changes to Customer’s civil infrastructure are part of a Toronto Hydro initiated enhancement project, Toronto Hydro may absorb the costs of modifications to the Customer’s civil infrastructure, provided the existing civil infrastructure has been maintained in satisfactory condition by the Customer.

j) The Customer shall maintain in proper working condition all Customer-Owned service disconnecting devices (such as main switch and secondary breakers) that Toronto Hydro may need to operate to ensure the safe operation and maintenance of the distribution system. Toronto Hydro shall not be liable for any loss or damage arising from Toronto Hydro’s operation of Customer-Owned service disconnecting devices and specifically will not be liable if a switch/breaker or other Customer equipment were to become inoperative or get damaged during or after its operation. Toronto Hydro may request that a waiver form be signed by the Customer acknowledging Toronto Hydro’s limited liability in such circumstances.

Refer to Tables 1.1, 1.2 and 1.3 and Table 2 of Section 5 of these Conditions of Service for Point of Demarcation, Standard Allowance and Connection Fees for General Service.

3.2.1 Electrical Requirements (as applicable)

For low voltage supply, the Customer's service entrance equipment shall be suitable to accept conductors installed by Toronto Hydro. The Customer's cables shall be brought to a point determined by Toronto Hydro for connection to Toronto Hydro’s supply.

The owner is required to supply and maintain an electrical room of sufficient size to accommodate the service entrance and meter requirements of the tenants and provide clear working space in accordance with the Ontario Electrical Safety Code.

In order to allow for an increase in load, the owner shall provide spare wall space so that at least 30% of the Customers supplied through meter sockets can accommodate meter cabinets at a later date.

Access doors, panels, slabs and vents shall be kept free from obstructing objects. The Customer will provide unimpeded and safe access to Toronto Hydro at all times for
the purpose of installing, removing, maintaining, operating or changing transformers and associated equipment.

The electrical room must be located to provide safe access from the outside or main hallway, and not from an adjoining room, so that it is readily accessible to Toronto Hydro’s employees and agents at all hours to permit meter reading and to maintain electric supply. This room must be locked. The owner shall install a pad bolt with mortise strike (Ackland Hardware, Cat. No. 199-10 or equivalent). Toronto Hydro shall provide a secure arrangement so that Toronto Hydro’s padlock can be installed as well as the Customer's lock.

The electrical room shall not be used for storage or contain equipment foreign to the electrical installation within the area designated as safe working space. All stairways leading to electrical rooms above or below grade shall have a handrail on at least one side as per the Ontario Building Code and shall be located indoors.

Outside doors providing access to electrical rooms must have at least 150 mm clearance between final grade and the bottom of the door. Electrical rooms ‘on' or 'below' grade must have a drain including a "P" trap complete with a non-mechanical priming device and a backwater valve connected to the sanitary sewer. The electrical room floor must slope 6 mm/300 mm or 2% towards the drain.

The electrical room shall have a minimum ceiling height of 2.2 m clear, be provided with adequate lighting at the working level, in accordance with Illuminating Engineering Society (I.E.S.) standards, and a 120 V convenience outlet. The lights and convenience outlet noted above and any required vault circuit shall be supplied from a panel located and clearly identified in the electrical room.

3.2.2 Underground Service Requirements

The Customer shall construct or install all civil infrastructure (including but not limited to poles, UG conduits, cable chambers, cable pull rooms, transformer room/vault/pad) on private property, that is deemed required by Toronto Hydro as part of its Connection Assets. All civil infrastructures are to be in accordance with Toronto Hydro’s current standards, practices, specifications and these Conditions of Service and are subject to Toronto Hydro’s inspection/acceptance.

The Customer is responsible to maintain all its structural and mechanical facilities on private property in a safe condition satisfactory to Toronto Hydro.

The trench route must be approved by Toronto Hydro. Any deviation from this route must also be approved by Toronto Hydro. The Customer will be responsible for Toronto Hydro’s costs associated with re-design and inspection services due to changes or deviations initiated by the Customer or its agents or any other body having jurisdiction.
Section 3 – CUSTOMER CLASS SPECIFIC

It is the responsibility of the owner or his/her contractor to obtain clearances from all of the utility companies (including Toronto Hydro) before digging.

It is the responsibility of the owner to contact Toronto Hydro to inspect each trench prior to the installation of Toronto Hydro’s cables.

3.3 General Service (Above 50 kW)

*Include all items that apply specifically to General Service Customers (above 50 kW) not covered under the General section. Describe the criteria to determine how a Customer is classified as being above 50 kW.*

All non-residential Customers with an average peak demand between 50 kW and 999 kW over the past twelve months are to be classified as General Services above 50 kW.

3.3.1 New Residential Subdivisions or Multi-Unit Developments

Customers of new Residential Subdivisions involving the construction of new city streets and roadways, or of Multi-unit Developments that are supplied from primary distribution systems built along private streets, are treated as Non-Residential Class Customers and will be subject to capital contribution for “expansion” work, in addition to any applicable Connection Fees. Should the Economic Evaluation identify a shortfall for the Expansion, the Developer has a choice of either completing the portion of plant not yet connected to Toronto Hydro’s system or have Toronto Hydro complete this work in accordance with Section 3.3 of the DSC Code, titled “Alternative Bids”. The Customer will not be allowed to complete construction work on Toronto Hydro’s existing distribution system.

All other Residential Subdivisions or Multi-unit complexes will follow the general terms and conditions for Connection Fees and capital contribution for the appropriate General Class Customers.

In all cases, all of the electrical service must be constructed to Toronto Hydro’s standards and in compliance with the Ontario Electrical Safety Code, applicable laws, regulations and codes.

All design work including service locations and trench routes must be approved by Toronto Hydro.

3.3.2 Electrical Requirements

Where the size of the Customer's electrical service warrants, as determined by Toronto Hydro, the Customer will be required to provide facilities on its property and an easement as required (i.e. on the premises to be served), acceptable to Toronto
Section 3 – CUSTOMER CLASS SPECIFIC

Hydro, to house the necessary transformer(s) and/or switching equipment. Toronto Hydro will provide planning details upon application for service.

Toronto Hydro will supply, install and maintain the electrical transformation equipment within the transformer vault or pad supplied by the Customer, at its expense, on the property. Toronto Hydro has the right to have this equipment connected to its distribution system.

The owner is required to supply and maintain an electrical room of sufficient size to accommodate the service entrance and meter requirements of the tenants and provide clear working space in accordance with the Ontario Electrical Safety Code.

In order to allow for an increase in load, the owner shall provide spare wall space so that at least 30% of the Customers supplied through meter sockets can accommodate meter cabinets at a later date.

The electrical room must be separate from, but adjacent to, the transformer vault. It must be located to provide safe access from the outside or main hallway, and not from an adjoining room, so that it is readily accessible to Toronto Hydro’s employees and agents at all hours to permit meter reading and to maintain electric supply. This room must be locked. The owner shall install a pad bolt with mortise strike (Ackland Hardware, Cat. No. 199-10 or equivalent). Toronto Hydro shall provide a secure arrangement so that Toronto Hydro’s padlock can be installed as well as the Customer's lock.

The electrical room shall not be used for storage or contain equipment not related to the electrical installation within the area designated by Toronto Hydro as safe working space. All stairways leading to electrical rooms above or below grade shall have a handrail on at least one side as per the Ontario Building Code, and shall be located indoors.

Outside doors providing access to electrical rooms must have at least 150 mm clearance between final grade and the bottom of the door. Electrical rooms ‘on’ or 'below' grade must have a drain including a "P" trap complete with a non-mechanical priming device and a backwater valve connected to the sanitary sewer. The electrical room floor must slope 6 mm/300 mm or 2% towards the drain.

The electrical room shall have a minimum ceiling height of 2.2 m clear, be provided with adequate lighting at the working level, in accordance with Illuminating Engineering Society (I.E.S.) standards, and a 120 V convenience outlet. The lights and convenience outlet noted above and any required vault circuit shall be supplied from a panel located and clearly identified in the electrical room.
The owner shall identify each tenant's metered service by address and/or unit number in a permanent and legible manner. The identification shall apply to all main switches, breakers and to all meter cabinets or meter mounting devices that are not immediately adjacent to the switch or breaker. The electrical room shall be visibly identified from the outside.

3.3.3 Technical Information

Where project drawings are required for Toronto Hydro’s approval, for items under Toronto Hydro’s jurisdiction, the Customer or its authorized representative must ensure that proposal drawings are fully in compliance with Toronto Hydro’s standards. Approval of project drawings by Toronto Hydro shall not relieve the Customer of its responsibility in respect of full compliance with Toronto Hydro’s standards and all applicable laws, regulations and codes. In all cases, one copy of all relevant drawings must be submitted to Toronto Hydro. Where the Customer requires an approved copy to be returned, two copies of all plans must be submitted.

Prior to the preparation of a design for a service, the Customer will provide the following information to Toronto Hydro as well as the approximate date that the Customer requires the electrical service and the due date that Toronto Hydro’s civil construction drawings are required in order to co-ordinate with site construction.

3.3.3.1 Site & Grading Plans

Indicate the lot number, plan numbers and, when available, the street number. The site plan shall show the location of the Building on the property relative to the property lines, any driveways and parking areas and the distance to the nearest intersection. All elevations shall be shown for all structures and proposed installations.

3.3.3.2 Mechanical Servicing Plan

Show the location on the property of all services proposed and/or existing such as water, gas, storm and sanitary sewers, telephone, et cetera.

3.3.3.3 Floor Plan

Show the service location, other services location, driveway, parking and indicate the total gross floor area of the building.

3.3.3.4 Duct Bank Location

Show the preferred routing of the underground duct bank on the property. This is subject to approval by Toronto Hydro.
3.3.3.5 Transformer Location

Indicate the preferred location on the property for the high voltage transformation. This is subject to approval by Toronto Hydro. Transformation will be vault, pad, submersible type or pole-mounted depending on the project load requirements.

3.3.3.6 Electrical Meter Room

Indicate preferred location in the building of the meter room and the main switchboard.

3.3.3.7 Single Line Diagram

Show the main service entrance switch capacity, the required supply voltage, and the number and capacity of all sub-services showing provision for metering facilities, as well as the connected load breakdown for lighting, heating, ventilation, air conditioning et cetera. Also, indicate the estimated initial kilowatt demand and ultimate maximum demands. Provide protection equipment information where coordination is required between Toronto Hydro and Customer owned equipment. Fusing will be determined later by Toronto Hydro to co-ordinate with the transformer size selected.

3.3.3.8 Switchgear

Submit three copies of any service entrance switchgear to be installed for Toronto Hydro’s approval, including interlocking arrangement if required.

3.3.3.9 Substation Information

Where a Customer-Owned substation is to be provided, the owner will be required to provide the following in addition to the site information outlined above.

- All details of the transformer, including kVA capacity, short circuit rating (in accordance with 3.3.4.1), primary and secondary voltages, impedance and cooling details.
- A site plan of the transformer station showing the equipment layout, proposed primary connections, grounding and fence details, where applicable.
- A coordination study for protection review.
3.3.4  Technical Considerations

3.3.4.1  Short Circuit Ratings

16000/27600 V Supply: The Customer's protective equipment shall have a three phase, short circuit rating of 800 MVA symmetrical. The asymmetrical current is 27,000 A (1.6 factor used).

8000/13800 V Supply: The Customer's protective equipment shall have a three phase, short circuit rating of 500 MVA symmetrical. The asymmetrical current is 34,000 A (1.6 factor used.)

2400/4160 V Supply: The Customer's protective equipment shall have a three phase, short circuit rating of 250 MVA symmetrical or 56,000 A asymmetrical (1.6 factor used).

347/600 V Supply: The Customer's protective equipment shall have a minimum short circuit rating of 50,000 A.

347/600 V Supply from network system: Available short circuit current may be obtained upon request to Toronto Hydro.

120/208 V Supply: Available short circuit current may be obtained upon request to Toronto Hydro.

3.3.4.2  Primary Fusing

All equipment connected to the Toronto Hydro’s distribution system shall satisfy the short circuit ratings specified in clause 3.3.4.1. The Customer and/or the Customer’s consultant shall specify the fuse link rating and demonstrate coordination with Toronto Hydro’s upstream protection including station breakers and/or distribution fuses. The Customer shall submit, at its expense, a coordination study to Toronto Hydro for verification to ensure coordination with upstream protection including station breakers and/or distribution fuses. The Customer shall maintain an adequate supply of spare fuses to ensure availability for replacement in the event of a fuse blowing.

3.3.4.3  Ground Fault Interrupting

Where ground fault protection is required to comply with the Ontario Electrical Safety Code, the method and equipment used shall be compatible with Toronto Hydro’s practice of grounding transformer neutral terminals in vaults. Zero sequence sensing will normally apply. Where ground strap sensing is used, the ground sensing devices shall be set to operate at 600 A if transformer and
switchboard buses are not bonded and 400 A if buses are bonded. Ground fault protection proposals for dual secondary supply arrangements shall be submitted to Toronto Hydro for approval, before construction of the switchboard.

### 3.3.4.4 Lightning Arresters

Customer installations that are directly supplied from Toronto Hydro’s primary underground system are not protected with lightning arresters. If the Customer wishes to install lightning arresters they shall be located on the load side of the first protective devices. For Customer installations that are supplied from Toronto Hydro’s primary overhead system, Toronto Hydro, at its expense, will install lightning arresters at the pole and the Customer, at its expense, may install lightning arresters in the switchgear on the load side of the incoming disconnect device. The mimic diagram shall indicate the presence of such devices in the switchgear.

### 3.3.4.5 Basic Impulse Level (B.I.L.)

The Customer's apparatus shall have a minimum Basic Impulse Level in accordance with the following:

- 2400/4160 supply voltage - 60 kV B.I.L.
- 8000/13800 supply voltage - 95 kV B.I.L.
- 16000/27600 supply voltage - Delta primary 150 kV B.I.L.
- 16000/27000 supply voltage - Grounded Wye primary 125 kV B.I.L.

### 3.3.4.6 Unbalanced Loads

On three-phase service, the unbalance due to single-phase loads shall not exceed 20% of the Customer's balanced phase loading expressed in kilowatts.

### 3.4 General Service (Above 1000 kW)

Include all items that apply specifically to General Service Customers (above 1000 kW) not covered under the General section. Describe the criteria to determine how a Customer is classified as being above 1000 kW.

All non-residential Customers with an average monthly demand of 1000 kW or higher, averaged over twelve consecutive months, as determined by Toronto Hydro, are to be classified as Customers over 1000 kW.

#### 3.4.1 Electrical Requirements

Where a primary service is provided to a Customer-Owned substation, the Customer shall install and maintain such equipment in accordance with all applicable laws,
Section 3 – CUSTOMER CLASS SPECIFIC

codes, regulations, and Toronto Hydro’s Customer Owned Substation requirements for high voltage installations. Toronto Hydro will provide planning details upon application for service.

Customer-Owned substations are a collection of transformers and switchgear located in a suitable room or enclosure owned and maintained by the Customer, and supplied at primary voltage: i.e. the Supply Voltage is greater than 750 volts.

High voltage distribution services are three-phase, three-wire or four-wire depending on the supply feeder. The Customer is required to bring out a neutral conductor for connection to the system neutral. If not required for Customer's use, this neutral shall be terminated to the Customer's station ground system. Toronto Hydro will provide Customer interface details and requirements for high voltage supplies.

Customer must provide transformers having voltage taps in their primary windings and configurations as shown in Table 4 in Section 5 of these Conditions of Service for all new, upgraded and refurbished installations. Transformers other than listed in Table 4 may be considered in like-for-like repair but shall not be connected without the specific written approval of Toronto Hydro.

Customer-Owned substations must be inspected by both the Electrical Safety Authority and Toronto Hydro. The owner will provide a pre-service inspection report to Toronto Hydro. A contractor acceptable to Toronto Hydro will prepare the certified report to Toronto Hydro.

The Customer shall inspect their own substations at minimum intervals of one year for outdoor substations and three years for indoor substations. Where an electricity disconnection may be required at Customer-Owned substations to perform inspections, maintenance, and installations, the Customer shall arrange a time for a disconnection by Toronto Hydro. For Toronto Hydro to perform the disconnection, Customers are required to pay a fair and reasonable charge based on cost recovery principles.

3.4.2 Technical Information and Considerations

The same information and considerations apply as for other General Service Customers. Refer to Subsection 3.3.3 and 3.3.4 for applicable requirements.

3.5 Embedded Generation Facilities

This section should include all terms and conditions applicable to the connection of embedded generation facility to the distributor (e.g., application process, engineering standards and operating agreements).
Section 3 – CUSTOMER CLASS SPECIFIC

For the terms and conditions applicable to the connection of a generation facility on the Toronto Hydro distribution system refer to the requirements outlined in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.

3.6 Wholesale Market Participant

Criteria for a Customer that is classified as being a Market Participant needs to be established. This section should describe any specific requirements for Customers that also are Market Participants.

Refer to the requirements outlined in Section 6, Reference #3 – “Toronto Hydro Distributed Generation Requirements”.

3.7 Embedded Distributor

This section should include all terms and conditions applicable to the connection of an Embedded Distributor.

All embedded distributors within the service jurisdiction of Toronto Hydro are required to inform Toronto Hydro of their status in writing 30 days prior to the supply of electricity from Toronto Hydro. The terms and conditions applicable to the connection of an embedded distributor shall be included in the Connection Agreement with Toronto Hydro.

An Embedded Distributor shall enter into a Connection Agreement in a form acceptable to Toronto Hydro. Until such time as the Embedded Distributor executes such a Connection Agreement with Toronto Hydro, the Embedded Distributor shall be deemed to have accepted and agreed to be bound by all of the terms in these Conditions of Service that apply to such Embedded Distributor.

3.8 Unmetered Connections

This section will include all terms and conditions applicable to unmetered connection.

Toronto Hydro, at its sole discretion, may provide for new service connections without a meter being installed. These loads would generally be small in size, non-variable, and supply a single device. Examples of services that are considered for unmetered supply include traffic & railway crossing signals, pedestrian x-walk signals/beacons, bus shelters, telephone booths, CATV amplifiers, TTC switching devices and other miscellaneous small fixed loads. Other loads less than 2 kW may also be considered for unmetered connections. Toronto Hydro will not provide a service connection to Customers requesting an unmetered supply connection for an electrical outlet (e.g. receptacle, GFI, and GFCI) installation.
Section 3 – CUSTOMER CLASS SPECIFIC

In all cases, the Customer shall contact Toronto Hydro for service supply requirements. The Customer shall provide manufacturer information and documentation with regard to electrical demand and expected hours of operation of the proposed unmetered load. Toronto Hydro may require, at its sole discretion, that the Customer provide at its own cost, a load study acceptable to Toronto Hydro in order to determine energy consumption.

The Customer shall notify Toronto Hydro prior to making any changes to existing equipment or adding new equipment that is to be supplied from the Toronto Hydro distribution system.

Where installations involve Toronto Hydro owned poles, the method and location of attachment are subject to the approval of Toronto Hydro. Toronto Hydro may, in its sole discretion, require the Customer to enter into an agreement with Toronto Hydro governing such attachments.

The Customer shall refer to Tables 9.1 to 9.4 in Section 5 of these Conditions of Service which describes the processes (including billing, data updating and validation), rights and obligations between Toronto Hydro and an unmetered load Customer.

The Customer shall construct, at its own expense, the civil infrastructure (including but not limited to poles, underground conduits, tap boxes) on public road allowances or private property that is deemed required by Toronto Hydro to house or support Toronto Hydro’s electrical equipment. This civil infrastructure shall be in accordance with Toronto Hydro’s current standards, practices, specifications and these Conditions of Service and are subject to inspection and acceptance by Toronto Hydro. After energization the Customer assets between the supply connection to the demarcation point shall be owned and maintained by Toronto Hydro.

Toronto Hydro will provide, at the Customer’s expense, for all breakouts of the Toronto Hydro civil infrastructure (i.e. cable chambers, vaults), which may be required to make the service connection. The Customer’s service connection equipment shall be able to accept conductors installed by Toronto Hydro. The Customer shall bring its cables to a point determined by Toronto Hydro.

Toronto Hydro shall make all new connections and final disconnections to and from Toronto Hydro’s distribution system. The Customer shall pay the applicable Connection Fees as outlined in Sections 3.8.1 to 3.8.3 and Table #3. Where “variable connection fees” apply, Toronto Hydro shall provide an estimate of the proposed work to the unmetered Customer. In turn, the unmetered Customer shall provide a response to proceed or not with the proposed work to Toronto Hydro within two weeks.
Section 3 – CUSTOMER CLASS SPECIFIC

The Customer shall maintain its civil infrastructure in a safe condition satisfactory to Toronto Hydro. Toronto Hydro will undertake the necessary programs to maintain and enhance its distribution plant. However, if during the course of Toronto Hydro’s work, relocation of Customer equipment is necessary, the Customer shall reimburse Toronto Hydro for all costs incurred for in relocating Customer’s infrastructure. More specifically, Toronto Hydro will provide standard overhead or underground supply services to unmetered Customers affected by Toronto Hydro’s construction activities at its own cost. However, where the unmetered Customer requests special construction beyond the normal Toronto Hydro standard installation, the unmetered Customer shall pay the additional cost, including engineering and administration fees.

Request for payment shall be subject to Toronto Hydro having provided the unmetered Customer with adequate advance notice, prior to effecting the relocation. The unmetered Customer shall respond within two weeks of its intended plan to modify, upgrade, or remove its plant. Customer’s unmetered loads include, but are not limited to Sections 3.8.1 to 3.8.3.

Toronto Hydro requires information related to the number of Customers and loads, including unmetered loads. This information provides inputs for the models used to allocate the costs of operating the distribution system to each of Toronto Hydro’s rate classes and in part determines the rates to be applied to collect these costs from each Customer class. To the extent that this information results in significant changes in allocated costs to the unmetered load classes, Toronto Hydro will endeavour to communicate these potential changes to its unmetered load Customers either through direct communication (e.g., phone, email or in-person contact between Toronto Hydro personnel and Customer representatives), through informational mailings (e.g., bill inserts), or through information provided on Toronto Hydro’s website.

3.8.1 Street Lighting

All services supplied to street lighting equipment owned by or operated for a municipality or the Province of Ontario shall be classified as Street Lighting Service.

In addition to complying with these Conditions of Service, all Street Lighting plant, facilities, or equipment owned by the Customer must comply with all Electrical Safety Authority (ESA) requirements.

The method and location of underground supply to Street Lighting plant from the Toronto Hydro distribution system will be established for each application through consultation with Toronto Hydro.

Charges related to the Connections of Street Lighting will be recovered via a Basic Connection Fee for a Standard Allowance/Basic Connection and a Variable Connection Fee (if applicable) consistent with the Ownership Demarcation Point.
defined in Table 3 in Section 5 of these Conditions of Service for various Street Lighting Distribution systems.

3.8.2 Traffic & Railway Crossing Signals, Pedestrian X-Walk Signals/Beacons, Bus Shelters, Telephone Booths, CATV Amplifiers, TTC Switching Devices, and Miscellaneous Small Fixed Loads

The above service types shall be classified as Unmetered Scattered Load Class Customers. Each unmetered location is reviewed individually and is connected to Toronto Hydro’s low voltage distribution system. Electrical Safety Authority (ESA) “Authorization to Connect” is required prior to connecting the service.

The nominal service voltage will be 120 Volts, single phase. The method and location of supply will be established for each application through consultation with Toronto Hydro. Supply connections to the municipal or the Province of Ontario’s street lighting systems will not be permitted.

The Ownership Demarcation Point for Customer electrical equipment attached to poles owned by Toronto Hydro is as follows:

- For Overhead Supply - the top of the Customer’s service standpipe/mast.
- For Underground Supply - the line side of the Customer’s circuit breaker panel on the pole (effective as of January 9, 2012).

The Ownership Demarcation Point for Customer-Owned electrical equipment, which is not attached to Toronto Hydro poles, is at the Customer’s disconnect enclosure attached to its structure (effective as of January 9, 2012), or at the top of the Customer’s service standpipe/mast.

Toronto Hydro may connect new Unmetered Scattered Load Customers using either an overhead or an underground supply. Overhead supply connections fall into two categories:

1) The source connection is made at an existing Toronto Hydro supply pole and the service mast is located on the same supply pole; or
2) The source connection is made at an existing Toronto Hydro distribution supply pole or line, without any extension of the secondary bus, and the service mast is located within 30 m of the existing pole or lines.

Toronto Hydro will recover the cost of the above two categories of overhead supply connections from the Customer via an Unmetered Basic Connection cost and if necessary, a Variable Connection cost. The Basic Connection cost is different depending on the category of overhead supply connection as described in Table 2 of Section 5 of these Conditions of Service. Variable Connection costs are charged for
installing assets that go beyond the assets included in the Basic Connection and are recovered on an actual cost basis. Both the Basic Connection and Variable Connection costs are charged to the Customer on a per location/installation basis.

For an underground supply connection, Toronto Hydro will recover the actual costs of the connection from the Customer. (As of May 1, 2014, Toronto Hydro does not define a basic connection or charge a Basic Connection cost for underground supply connections.)

Re-design and inspection services are at the expense of the Customer. The Customer is responsible for maintaining and repairing its equipment and/or facilities.

3.8.3 Other Loads (<2 kW) - Decorative Lighting and Tree Lighting Services

This section applies to the distribution and supply of electrical energy for decorative lighting. These installations are typically owned and maintained by a local Business Improvement Association (BIA) as a way to improving streetscape or for specific festive occasions. In addition to complying with these Conditions of Service, all such installations must comply with the Ontario Electric Safety Code and are subject to the approval of ESA.

This section does not apply to decorative lighting that is owned by, or operated for, a municipality or the Province of Ontario.

Decorative Lighting and Tree Lighting connected to Toronto Hydro’s distribution system shall have the same terms and conditions as outlined in Section 3.8.2 of these Conditions of Service.
Section 4 – GLOSSARY OF TERMS

4 GLOSSARY OF TERMS

The Conditions of Service document may contain a variety of terms that should be defined in the context of this document. Where possible, glossary terms should reflect definitions in existing documents that apply to the distributor, such as the DSC Code, the Distributor's licence and Standard Supply Service Code. The text of the Conditions of Service document should be used to expand on these definitions as applicable to the Distributor.

Sources for definitions:

Electricity Act, 1998, Schedule A, Section 2, Definitions
MR Market Rules for the Ontario Electricity Market, Chapter 11, Definitions
DSC Distribution System Code Definitions
RSC Retail Settlement Code Definitions
EDL Electricity Distribution Licence

“Accounting Procedures Handbook” means the handbook approved by the Board and in effect at the relevant time, which specifies the accounting records, accounting principles and accounting separation standards to be followed by the distributor; (DSC)

“Affiliate Relationships Code” means the code, approved by the Board and in effect at the relevant time, which establishes the standards and conditions for the interaction between electricity distributors or transmitters and their respective affiliated companies; (DSC)

“ancillary services” means services necessary to maintain the reliability of the IESO-controlled grid; including frequency control, voltage control, reactive power and operating reserve services; (MR, DSC)

"apartment building" means a structure containing four or more dwelling units having access from an interior corridor system or common entrance;

"apparent power" means the total power measured in kiloVolt Amperes (kVA);

"application for service" means the agreement or contract with Toronto Hydro under which electrical service is requested;

“bandwidth” means a distributor’s defined tolerance used to flag data for further scrutiny at the stage in the VEE (validating, estimating and editing) process where a current reading is compared to a reading from an equivalent historical billing period. For example, a 30 percent bandwidth means a current reading that is either 30 percent lower or 30 percent higher than the measurement from an equivalent historical billing period will be identified by the VEE process as requiring further scrutiny and verification; (DSC)
"billing demand" means the metered demand or connected load after necessary adjustments have been made for power factor, intermittent rating, transformer losses and minimum billing. A measurement in kiloWatts (kW) of the maximum rate at which electricity is consumed during a billing period;

“Board” or “OEB” means the Ontario Energy Board; (A, DSC)

“building” means a building, portion of a building, structure or facility;

“competitive sector multi-unit residential service” means a service where electricity is used exclusively for residential purposes in a multi-unit residential building, where unit metering is provided using technology that is substantially similar to that employed by competitive sector sub-metering providers;

“complex metering installation” means a metering installation where instrument transformers, test blocks, recorders, pulse duplicators and multiple meters may be employed; (DSC)

“Conditions of Service” means the document developed by a distributor in accordance with subsection 2.4 of the Code that describes the operating practices and connection rules for the distributor; (DSC)

“connection” means the process of installing and activating connection assets in order to distribute electricity; (DSC)

“Connection Agreement” means an agreement entered into between a distributor and a person connected to its distribution system that delineates the conditions of the connection and delivery of electricity to or from that connection; (DSC)

“connection assets” means that portion of the distribution system used to connect a Customer to the existing main distribution system, and consists of the assets between the point of connection on a distributor’s main distribution system and the ownership demarcation point with that Customer; (DSC)

“Consumer” means a person who uses, for the person’s own consumption, electricity that the person did not generate; (A, MR, DSC)

“Customer” means a person that has contracted for or intends to contract for connection of a building or an embedded generation facility. This includes developers of residential or commercial sub-divisions; (DSC)

"demand" means the average value of power measured over a specified interval of time, usually expressed in kilowatts (kW). Typical demand intervals are 15, 30 and 60 minutes; (DSC)
Section 4 – GLOSSARY OF TERMS

“demand meter” means a meter that measures a Consumer’s peak usage during a specified period of time; (DSC)

"developer" means a person or persons owning property for which new or modified electrical services are to be installed;

“disconnection” means a deactivation of connection assets that results in cessation of distribution services to a Consumer; (DSC)

“distribute”, with respect to electricity, means to convey electricity at voltages of 50 kilovolts or less; (A, MR, DSC)

“distribution losses” means energy losses that result from the interaction of intrinsic characteristics of the distribution network such as electrical resistance with network voltages and current flows; (DSC)

“distribution loss factor” means a factor or factors by which metered loads must be multiplied such that when summed equal the total measured load at the supply point(s) to the distribution system; (RSC)

“distribution services” means services related to the distribution of electricity and the services the Board has required distributors to carry out; (RSC, DSC)

“distribution system” means a system for distributing electricity, and includes any structures, equipment or other things used for that purpose. A distribution system is comprised of the main system capable of distributing electricity to many Customers and the connection assets used to connect a Customer to the main distribution system; (A, MR, DSC)

“Distribution System Code” means the code, approved by the Board, and in effect at the relevant time, which, among other things, establishes the obligations of the distributor with respect to the services and terms of service to be offered to Customers and retailers and provides minimum technical operating standards of distribution systems; (DSC)

“distributor” means a person who owns or operates a distribution system; (A, MR, DSC)

"duct bank" means two or more ducts that may be encased in concrete used for the purpose of containing and protecting underground electric cables;

Section 4 – GLOSSARY OF TERMS

“Electrical Safety Authority” or “ESA” means the person or body designated under the *Electricity Act* regulations as the Electrical Safety Authority; (DSC)

"electric service" means the Customer’s conductors and equipment for energy from Toronto Hydro;

“eligible low-income customer” means: (a) a residential electricity consumer who has been approved for the Ontario Electricity Support Program, or (b) a residential electricity consumer who has been approved for the Low-Income Energy Assistance Program; (based on DSC section 1.2)

“embedded distributor” means a distributor who is not a wholesale market participant and that is provided electricity by a host distributor; (RSC, DSC)

“embedded generation facility” means a generation facility which is not directly connected to the IESO-controlled grid but instead is connected to a distribution system, and has the extended meaning given to it in section 1.9; (DSC)

“emergency” means any abnormal system condition that requires remedial action to prevent or limit loss of a distribution system or supply of electricity that could adversely affect the reliability of the electricity system; (DSC)

“emergency backup generation facility” means a generation facility that has a transfer switch that isolates it from a distribution system; (DSC)

"energy" means the product of power multiplied by time, usually expressed in kilowatt-hours (kWH);


"energy diversion" means the electricity consumption unaccounted for but that can be quantified through various measures upon review of the meter mechanism, such as unbilled meter readings, tap off load(s) before revenue meter or meter tampering;

“enhancement” means a modification to the main distribution system that is made to improve system operating characteristics such as reliability or power quality or to relieve system capacity constraints resulting, for example, from general load growth, but does not include a renewable enabling improvement; (DSC)

“expansion” means a modification or addition to the main distribution system in response to one or more requests for one or more additional customer connections that otherwise could not be made, for example, by increasing the length of the main distribution system, and includes the modifications or additions to the main
Section 4 – GLOSSARY OF TERMS

distribution system identified in section 3.2.30 but in respect of a renewable energy generation facility excludes a renewable enabling improvement; (DSC)

"extreme operating conditions" means extreme operating conditions as defined in the Canadian Standards Association ("CSA") Standard CAN3-C235-87 (latest edition);

“four-quadrant interval meter” means an interval meter that records power injected into a distribution system and the amount of electricity consumed by the Customer; (DSC)

"general service" means any service supplied to premises other than those designated as Residential and less than 50kW, Large User, or Municipal Street Lighting. This includes multi-unit residential establishments such as apartments buildings supplied through one service (bulk-metered);

“generate”, with respect to electricity, means to produce electricity or provide ancillary services, other than ancillary services provided by a transmitter or distributor through the operation of a transmission or distribution system; (A, DSC)

“generation facility” means a facility for generating electricity or providing ancillary services, other than ancillary services provided by a transmitter or distributor through the operation of a transmission or distribution system, and includes any structures, equipment or other things used for that purpose; (A, MR, DSC)

“generator” means a person who owns or operates a generation facility; (A, MR, DSC)

“geographic distributor,” with respect to a load transfer, means the distributor that is licensed to service a load transfer Customer and is responsible for connecting and billing the load transfer Customer; (DSC)

“good utility practice” means any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry in North America during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgement in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good practices, reliability, safety and expedition. Good utility practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in North America; (MR, DSC)

“host distributor” means the distributor who provides electricity to an embedded distributor; (DSC)
"house service" means that portion of the electrical service in a multiple occupancy facility which is common to all occupants, (i.e. parking lot lighting, sign service, corridor and walkway lighting, et cetera);

“IEC” means International Electrotechnical Commission;

“IEEE” means Institute of Electrical and Electronics Engineers;

“IESO” means the Independent Electricity System Operator;

“IESO-controlled grid” means the transmission systems with respect to which, pursuant to agreements, the IESO has authority to direct operation; (A, DSC)

“interval meter” means a meter that measures and records electricity use on an hourly or sub-hourly basis; (RSC, DSC)

"large user" means a Customer with a monthly peak demand of 5000 kW or greater, regardless the demand occurs in the peak or off-peak periods, averaged over 12 months;

"load factor" means the ratio of average demand for a designated time period (usually one month) to the maximum demand occurring in that period;

“load transfer” means a network supply point of one distributor that is supplied through the distribution network of another distributor and where this supply point is not considered a wholesale supply or bulk sale point; (DSC)

“load transfer Customer” means a Customer that is provided distribution services through a load transfer; (DSC)

“main distribution system” means a distribution system less the connection assets;

"main service" refers to Toronto Hydro’s incoming cables, bus duct, disconnecting and protective equipment for a Building or from which all other metered sub-services are taken;

“market participant” has the meaning prescribed in the Market Rules;

“Market Rules” means the rules made under section 32 of the Electricity Act; (MR, EDL, DSC)

“Measurement Canada” means the Special Operating Agency established in August 1996 by the Electricity and Gas Inspection Act, 1980-81-82-83, c. 87., and Electricity and Gas Inspection Regulations (SOR/86-131; (DSC)
Section 4 – GLOSSARY OF TERMS

“meter service provider” means any entity that performs metering services on behalf of a distributor or generator; (DSC)

“meter installation” means the meter and, if so equipped, the instrument transformers, wiring, test links, fuses, lamps, loss of potential alarms, meters, data recorders, telecommunication equipment and spin-off data facilities installed to measure power past a meter point, provide remote access to the metered data and monitor the condition of the installed equipment; (RSC, DSC)

"meter socket" means the mounting device for accommodating a socket type revenue meter;

“metering services” means installation, testing, reading and maintenance of meters; (DSC)

“MIST meter” means an interval meter from which data is obtained and validated within a designated settlement timeframe. MIST refers to “Metering Inside the Settlement Timeframe;” (RSC, DSC)

“MOST meter” means an interval meter from which data is only available outside of the designated settlement timeframe. MOST refers to “Metering Outside the Settlement Timeframe;” (RSC, DSC)

"multiple dwelling" means a Building which contains more than one self-contained dwelling unit;

"municipal street lighting" means all services supplied to street lighting equipment owned and operated for a municipal corporation;

“non-competitive electricity costs” means costs for services from the IESO that are not deemed by the Board to be competitive electricity services plus costs for distribution services, other than Standard Supply Service (SSS); (RSC)

“normal operating conditions” means the operating conditions comply with the standards set by the Canadian Standards Association ("CSA") Standard CAN3-C235-87 (latest edition);


Section 4 – GLOSSARY OF TERMS

“operational demarcation point” means the physical location at which a distributor’s responsibility for operational control of distribution equipment including connection assets ends at the Customer; (DSC)

“ownership demarcation point” means the physical location at which a distributor’s ownership of distribution equipment including connection assets ends at the Customer; (DSC)

“performance standards” means the performance targets for the distribution and connection activities of the distributor as established by the Board pursuant to the Ontario Energy Board Act and in the Rate Handbook;

"person" includes an individual, a corporation, sole proprietorship, partnership, unincorporated organization, unincorporated association, body corporate, and any other legal entity;

“physical distributor,” with respect to a load transfer, means the distributor that provides physical delivery of electricity to a load transfer Customer, but is not responsible for connecting and billing the load transfer Customer directly; (DSC)

"plaza" means any Building containing two or more commercial business tenants;

“point of supply,” with respect to an embedded generation facility, means the connection point where electricity produced by the generation facility is injected into the distribution system; (DSC)

"power factor” means the ratio between Real Power and Apparent Power (i.e. kW/kVA);

"primary service" means any service which is supplied with a nominal voltage greater than 750 volts;

"private property" means the property beyond the existing public street allowances;

“rate” means any rate, charge or other consideration, and includes a penalty for late payment; ( DSC)

“Rate Handbook” means the document approved by the Board that outlines the regulatory mechanisms that will be applied in the setting of distributor rates; (RSC, DSC)

"reactive power" means the power component which does not produce work but is necessary to allow some equipment to operate, and is measured in kiloVolt Amperes Reactive (kVAR);
Section 4 – GLOSSARY OF TERMS

"real power" means the power component required to do real work, which is measured in kiloWatts (kW);

“Regulations” means the regulations made under the *Ontario Energy Board Act* or the *Electricity Act*;

“reinforcement” means an investment that a distributor makes to increase the distribution system capacity to accommodate new load on the distributor’s distribution system, consistent with the distributor’s planning, design, and construction standard.

“residential customer” means a Customer that receives either a “residential service” or a “competitive sector multi-unit residential service”;

"residential service" means a service where electricity is used exclusively for residential purposes in a separately metered living accommodation, where the “competitive sector multi-unit residential service” is not applicable. Eligibility is restricted to a dwelling unit that consists of a detached house or one unit of a semi-detached, duplex, triplex or quadruplex building, with a residential zoning; a separately metered dwelling within a town house complex or apartment building; and bulk metered residential buildings with six or fewer units;

“retail”, with respect to electricity means,

   a) to sell or offer to sell electricity to a Consumer
   b) to act as agent or broker for a retailer with respect to the sale or offering for sale of electricity, or
   c) to act or offer to act as an agent or broker for a Consumer with respect to the sale or offering for sale of electricity; (A, MR, DSC)

“Retail Settlement Code” means the code approved by the Board and in effect at the relevant time, which, among other things, establishes a distributor’s obligations and responsibilities associated with financial settlement among retailers and Consumers and provides for tracking and facilitating Consumers transfers among competitive retailers; (DSC)

“retailer” means a person who retails electricity; (A, MR, DSC)

"secondary service" means any service which is supplied with a nominal voltage less than 750 Volts;

“service agreement” means the agreement that sets out the relationship between a licensed retailer and a distributor, in accordance with the provisions of Chapter 12 of the Retail Settlement Code; (RSC)
Section 4 – GLOSSARY OF TERMS

“service area,” with respect to a distributor, means the area in which the distributor is authorized by its license to distribute electricity; (A, EDL, DSC)

"service date" means the date that the Customer and Toronto Hydro mutually agree upon to begin the supply of electricity by Toronto Hydro;

“Standard Supply Service Code” means the code approved by the Board which, among other things, establishes the minimum conditions that a distributor must meet in carrying out its obligations to sell electricity under section 29 of the Electricity Act; (EDL)

"sub-service" means a separately metered service that is taken from the main Building service;

"supply voltage" means the voltage measured at the Customer's main service entrance equipment (typically below 750 volts). Operating conditions are defined in the Canadian Standards Association ("CSA") Standard CAN3-C235 (latest edition);

"temporary service" means an electrical service granted temporarily for such purposes as construction, real estate sales, trailers, et cetera;

"terminal pole" refers to the Toronto Hydro’s distribution pole on which the service supply cables are terminated;

“Timed Load Interrupter Device” means a device that will completely interrupt the customer’s electricity intermittently for periods of time and allows full load capacity outside of the time periods that the electricity is interrupted; (DSC)

“total losses” means the sum of distribution losses and unaccounted for energy; (DSC)

“totalization” is the process of aggregating, within Toronto Hydro’s meter data management system, interval data from two or more interval meters that serve separate delivery points for the purpose of creating a virtual meter point whose peak load is less than the sum of the individual interval meters.

"transformer room" means an isolated enclosure built to applicable codes to house transformers and associated electrical equipment;

“transmission system” means a system for transmitting electricity, and includes any structures, equipment or other things used for that purpose; (A, MR, DSC)

“Transmission System Code” means the code, approved by the Board, that is in force at the relevant time, which regulates the financial and information obligations of the
Section 4 – GLOSSARY OF TERMS

Transmitter with respect to its relationship with Customers, as well as establishing the standards for connection of Customers to, and expansion of a transmission system; (DSC)

“transmit”, with respect to electricity, means to convey electricity at voltages of more than 50 kilovolts; (A, DSC)

“transmitter” means a person who owns or operates a transmission system; (A, MR, DSC)

“unaccounted for energy” means all energy losses that can not be attributed to distribution losses. These include measurement error, errors in estimates of distribution losses and unmetered loads, energy theft and non-attributable billing errors; (DSC)

“unmetered loads” means electricity consumption that is not metered and is billed based on estimated usage; (DSC)

“validating, estimating and editing (VEE)” means the process used to validate, estimate and edit raw metering data to produce final metering data or to replicate missing metering data for settlement purposes; (MR, DSC)

“wholesale market participant”, means a person that sells or purchases electricity or ancillary services through the IESO- administered markets; (RSC, DSC)
Section 5 – TABLES

5 TABLES

Table 1.1 Demarcation Points & Charges for Connection Assets and Disconnection for Class 1 and Class 2 Customers

Table 1.2 Demarcation Points & Charges for Connection Assets and Disconnection for Class 3A Customers

Table 1.3 Demarcation Points & Charges for Connection Assets and Disconnection for Class 3(B-C), Class 4 and Class 5 Customers

Table 1.4 Demarcation Points & Charges for Connection Assets and Disconnection for Unmetered Connections

Table 2 Basic Connection Fee and Disconnection Fee

Table 3 Street Lighting Service – Points of Demarcation & Connection Charges

Table 4 Customer-Owned Transformers (Article 3.4.1)

Table 5 Meter Sockets (Article 2.3.7.1.2)

Table 6 Meter Cabinets (Article 2.3.7.1.2)

Table 7 Instrument Transformers and Enclosures (Article 2.3.7.2)

Table 8 Meter Centres (Article 2.3.7.1.2)

Table 9.1 Unmetered Scatter Load Process Map: Customer Connection / Transfer / Disconnection / Removal Services

Table 9.2 Toronto Hydro / Customer Interactions for Table 9.1 Process Map: Customer Connection/Transfer/Disconnection/Removal Services

Table 9.3 Unmetered Scatter Load Process Map: Existing Customer Service Updates and Validation

Table 9.4 Toronto Hydro / Customer Interactions for Table 9.3 Process Map: Existing Customer Service Updates and Validation
## Section 5 – TABLES

### TABLE 1.1 Demarcation Points & Charges for Connection Assets and Disconnection

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Standard Allowance (Basic Connection)</th>
<th>Basic Connection Fee (for Std. Allowance)</th>
<th>Variable Connection Fee</th>
<th>Additional Services charged to Customer (as part of Var. Connections)</th>
<th>Connection Termination Fee (Initiated by customer request)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLASS 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential - Single service</td>
<td></td>
<td>up to 30 m OH service lines from Distributor's &quot;feed&quot; pole or lines. Includes connections at feed pole or lines, at customer's service mast, and equivalent average credit for transformation equipment.</td>
<td>Recovered through Distributor's rates</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Customers requesting an UG service in OH area will be required to pay 100% connection costs less the Standard allowance for an OH service.</td>
<td>Recovered through Distributor's Tariffs or rates. See Table 2</td>
</tr>
<tr>
<td>Overhead</td>
<td>Top of Customer's service mast</td>
<td>Recovered through Distributor's rates</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Customers requesting an UG service in OH area will be required to pay 100% connection costs less the Standard allowance for an OH service.</td>
<td>Recovered through Distributor's Tariffs or rates. See Table 2</td>
<td></td>
</tr>
<tr>
<td>Underground</td>
<td>Line side of Customer's meter base</td>
<td>Recovered through Distributor's rates</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance, including street crossing. If Customer's load requires transformation facilities on Customer's property, refer to &quot;General Service&quot; Rate Class category for Underground service with Transformation.</td>
<td>Customers requesting an UG service in OH area will be required to pay 100% connection costs less the Standard allowance for an OH service.</td>
<td>Recovered through Distributor's Tariffs or rates. See Table 2</td>
<td></td>
</tr>
</tbody>
</table>

| **CLASS 2**         |                             |                                        |                                          |                        |                                                                    |                                                          |
| General Service 0 < 50 kW |                             | equivalent credit to Class 1 Residential Overhead Single Service | Recovered through Distributor's rates | Customer charged Actual costs for connection assets beyond standard allowance. | Additional or redesign due to changes in Customer initial proposal; electrical inspections more than standard allowance | Recovered through Distributor's Tariffs or rates. See Table 2 |
| Overhead - Single Service | Top of Customer's service mast | Recovered through Distributor's rates | Customer charged Actual costs for connection assets beyond standard allowance. | Additional or redesign due to changes in Customer initial proposal; electrical inspections more than standard allowance | Recovered through Distributor's Tariffs or rates. See Table 2 |
| Underground - Single Service | Line side of Customer's main disconnect switch | Recovered through Distributor's rates | Customer charged Actual costs for connection assets beyond standard allowance. | Additional or redesign due to changes in Customer initial proposal; electrical inspections more than standard allowance | Recovered through Distributor's Tariffs or rates. See Table 2 |

Inspections more than standard allowance and all civil inspections.
### TABLE 1.2 Demarcation Points & Charges for Connection Assets and Disconnection

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Standard Allowance (Basic Connection)</th>
<th>Basic Connection Fee (for Std. Allowance)</th>
<th>Variable Connection Fee</th>
<th>Additional Services charged to Customer (as part of Var. Connections)</th>
<th>Connection Termination Fee (Initiated by customer request)</th>
</tr>
</thead>
</table>
| **CLASS 3-A**  
**General Service 50 kW - 999 kW** |                             |                                        |                                           |                         |                                                                     |                                                          |
| Overhead - Single building | Top of Customer's service mast | equivalent credit to Class 1 | See Table 2 | Customer charged Actual costs for connection assets beyond standard allowance. | Additional or redesign due changes in Customer initial proposal; electrical inspections more than standard allowance | Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point. See Table 2 |
| Bulk Metered or Suite Metering (Not requiring Transformation)  
Facilities on private property | | | | | | |
| Underground - Single Building | Line side of Customer's main disconnect switch | equivalent credit to Class 1 | See Table 2 | Customer charged Actual costs for connection assets beyond standard allowance, including cable chamber(s), UG conduits as required. | Additional or redesign due changes in Customer initial proposal; electrical inspections more than standard allowance | Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point. See Table 2 |
| Bulk Metered or Suite Metering (Not requiring Transformation)  
Facilities on private property | | | | | | |
| Overhead - Single Building | Line side of Customer's main disconnect switch (secondary UG)  
OR top of Customer's service mast (secondary OH) | equivalent credit to Class 1 | See Table 2 | Customer charged Actual costs for connection assets beyond standard allowance, including transformer(s), Tx. connections, associated switching equipment, transformer pole(s), cable chamber(s), UG conduits as applicable. | Additional or redesign due changes in Customer initial proposal; electrical inspections more than standard allowance and all civil inspections. | Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and, related feeder switching and scheduling. |
| Bulk Metered or Suite Metering (Requiring Transformation)  
Facilities on private property | | | | | | |
| Underground - Single Building | Line side of Customer's main disconnect switch or Customer's bus | equivalent credit to Class 1 | See Table 2 | Customer charged Actual costs for connection assets beyond standard allowance, including transformer(s), Tx. connections, associated switching equipment, transformer vaults, cable chambers, cable pull rooms, UG conduits and cabling and road crossing (as applicable). | Additional or redesign due changes in Customer initial proposal; electrical inspections more than standard allowance and all civil inspections and related feeder switching/scheduling | Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and related feeder switching and scheduling. |
| Bulk Metered or Suite Metering (Requiring Transformation)  
Facilities on private property | | | | | | |
### TABLE 1.3 Demarcation Points & Charges for Connection Assets and Disconnection

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Standard Allowance (Basic Connection)</th>
<th>Basic Connection Fee (for Std. Allowance)</th>
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<th>Additional Services charged to Customer (as part of Var. Connections)</th>
<th>Connection Termination Fee (Initiated by customer request)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLASS 3-B</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>General Service 50 kW - 999 kW</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underground</td>
<td>(Bulk meter)</td>
<td>equivalent credit to Class 1</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and related feeder switching and scheduling.</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>(Multi-units or Townhouse Complex with Transformation Facilities on private property other than supplied from primary distribution systems built along private streets)</td>
<td>First point of connection past transformers on private property as applicable, i.e.</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>Underground</td>
<td>(Bulk meter)</td>
<td>equivalent credit to Class 1</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>(Multi-units or Townhouse Complex with NO Transformation Facilities on private property or supplied from primary distribution system built along private streets)</td>
<td>First point of connection past Distributors's system onto private</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>Underground</td>
<td>(Bulk meter)</td>
<td>equivalent credit to Class 1</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>(Multi-units or Townhouse Complex)</td>
<td>First point of connection past private as applicable i.e.</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>Underground</td>
<td>(Bulk meter)</td>
<td>equivalent credit to Class 1</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance.</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>(Multi-units or Townhouse Complex with Transformation Facilities on private property other than supplied from primary distribution systems built along private streets)</td>
<td>First point of connection past transformers on private property as applicable, i.e.</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Additional or redesign due to changes in Customer initial proposal; electrical inspections more than std. allow and all civil inspections and related feeder switching/scheduling.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets up to the demarcation point. See Table 2</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td><strong>CLASS 3-C</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Residential Subdivision</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(development with more than 5 lots)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underground Single/Multi-pe Building Bulk Metered or Suite Metering (Requiring Transformation Facilities on private property)</td>
<td>Line side of Customer's main bus</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance, including transformer(s), Tx. connections, associated switching equipment, transformer pads, transformer vaults, cable chambers, cable pull rooms, UG conduits, excess cabling and street crossings.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and related feeder switching and scheduling.</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>Underground Single/Multi-pe Building Bulk Metered or Suite Metering (Requiring Transformation Facilities on private property)</td>
<td>Line side of Customer's main bus</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance, including transformer(s), Tx. connections, associated switching equipment, transformer pads, transformer vaults, cable chambers, cable pull rooms, UG conduits, excess cabling and street crossings.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and related feeder switching and scheduling.</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
<tr>
<td>Underground Single/Multi-pe Building Bulk Metered or Suite Metering (Customer-Owned Sub-Station) (Requiring Transformation Facilities on private property)</td>
<td>Line side of Customer's main bus</td>
<td>Residential Overhead Single Service</td>
<td>See Table 2</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance, including transformer(s), Tx. connections, associated switching equipment, transformer pads, transformer vaults, cable chambers, cable pull rooms, UG conduits, excess cabling and street crossings.</td>
<td>Customer charged actual costs associated with the disconnection and/or removal of connection assets including cables, transformers and related vault equipment up to the demarcation point and related feeder switching and scheduling.</td>
<td>Recovered through Distributors' Tariffs or rates.</td>
</tr>
</tbody>
</table>

**Note:** Individual Suite Metering will negate the Transformer Allowance Discount.

### Conditions of Service

98
### TABLE 1.4 Demarcation Points & Charges for Connection Assets and Disconnection

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Standard Allowance (Basic Connection)</th>
<th>Basic Connection Fee (for Std. Allowance)</th>
<th>Variable Connection Fee charged to customer (as part of Var. Connections)</th>
<th>Additional Services charged to customer (as part of Var. Connections)</th>
<th>Connection Termination Fee (initiated by customer request)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unmetered Connections (excluding street lighting)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead-Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Source connection is made at Distributor’s a) Top of Customer’s service mast; or supply pole and the service mast is located on the same supply pole b) Customer’s disconnect enclosure</td>
<td>Source connection is made at Distributor’s supply pole</td>
<td>See Table 2</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance</td>
<td>Additional or redesign due to changes in Customer initial proposal.</td>
<td>Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point.</td>
<td></td>
</tr>
<tr>
<td>(2) Source connection is made at Distributor’s a) Top of Customer’s service mast; or supply pole (or lines), and the service mast b) Customer’s disconnect enclosure is not located on the same supply pole</td>
<td>Source connection (up to 30 m of service lines) from Distributor’s supply pole or line to service mast that is not located on the same supply pole</td>
<td>See Table 2</td>
<td>Customer charged Actual costs for connection assets beyond standard allowance</td>
<td>Additional or redesign due to changes in Customer initial proposal.</td>
<td>Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point.</td>
<td></td>
</tr>
<tr>
<td>Underground-Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Customer attachments on Distributor’s poles</td>
<td>Line side of Customer’s circuit breaker panel on pole</td>
<td>No standard allowance</td>
<td>not applicable</td>
<td>Customer charged Actual costs for connection assets.</td>
<td>Additional or redesign due to changes in Customer initial proposal.</td>
<td>Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point.</td>
</tr>
<tr>
<td>(2) Customer attachments not on Distributor’s poles</td>
<td>Customer’s disconnect enclosure at Customer’s structure</td>
<td>Source connection at Distributor’s structure (tap box, cable chamber), No standard allowance</td>
<td>not applicable</td>
<td>Customer charged Actual costs for connection assets.</td>
<td>Additional or redesign due to changes in Customer initial proposal.</td>
<td>Customer charged actual costs associated with disconnection and/or removal of connection assets up to the demarcation point.</td>
</tr>
</tbody>
</table>
### Section 5 – TABLES

#### TABLE 2 Service Connection and Disconnection Fee

**IMPORTANT:**
The range of services listed below may not be applicable in all districts due to the restrictions imposed by the distribution system in certain areas.

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Service Connection Fee (*)</th>
<th>Connection Termination Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLASS 1 - Residential - Single Service</strong></td>
<td>Top of Customer’s service mast</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(No charge - Recovered through rates)</td>
</tr>
<tr>
<td>Overhead</td>
<td>Line side of Customer’s meter base</td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td>(No charge - Recovered through rates)</td>
</tr>
<tr>
<td>Underground (Not requiring Transformation Facilities on customer's property)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLASS 2 - General Service 0 - 50 kW</strong></td>
<td>Top of Customer’s service mast</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(No charge - Recovered through rates)</td>
</tr>
<tr>
<td>Overhead - Single Service</td>
<td>Line side of Customer’s main disconnect switch</td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td>(No charge - Recovered through rates)</td>
</tr>
<tr>
<td>Underground - Single Service (Not requiring Transformation Facilities on customer's property)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLASS 3A - General Service 50 kW - 999 kW</strong></td>
<td>Top of Customer’s service mast</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>Overhead - Single Service (Not requiring Transformation Facilities on private property)</td>
<td>Line side of Customer’s main disconnect switch</td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>Underground - Single Service (Not requiring Transformation Facilities on private property)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLASS 3B - General Service 50 kW - 999 kW</strong></td>
<td>Top of Customer’s service mast</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>(Multi-units or Townhouse Complex with Transformation Facilities on private property other than supplied from primary distribution systems built along private streets)</td>
<td></td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td></td>
</tr>
<tr>
<td>Bulk meter</td>
<td>First point of connection past transformers on private property</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Tx. Secondary spade</td>
<td></td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td></td>
</tr>
<tr>
<td>b) meter center</td>
<td></td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td></td>
</tr>
<tr>
<td>c) cable chamber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) tap box</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Townhouse individual meter)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line side of Customer’s meter base</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLASS 3C</strong></td>
<td><strong>Residential Subdivision</strong> (development with more than 5 lots)</td>
<td>Line side of Customer’s meter base</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
</tr>
<tr>
<td>Top of Customer’s service mast</td>
<td></td>
<td>- Variable Connection Charges collected directly from the Customer</td>
<td></td>
</tr>
</tbody>
</table>

(*) Typical connection costs by Class of Customers are available upon request.

100
### TABLE 2 (continued) - Service Connection and Disconnection Fee

**IMPORTANT:**
The range of services listed below may not be applicable in all districts due to the restrictions imposed by the distribution system in certain areas.

<table>
<thead>
<tr>
<th>Rate/Customer Class</th>
<th>Ownership Demarcation Point</th>
<th>Service Connection Fee (*)</th>
<th>Connection Termination Fee (Initiated by Customer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLASS 4 &amp; 5 - General Service 1000 kW and Up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underground (Requiring Transformation Facilities on private property)</td>
<td>Line side of Customer's main bus</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>Underground (Customer-Owned Sub-Station)</td>
<td>Pot head Terminations at line side of Customer's high voltage switchgear</td>
<td>- Basic Connection Charge recovered through hydro rates ($1,396.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>Unmetered Connections (excluding street lighting)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overhead Supply:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Source connection is made at Distributor’s supply pole and the service mast is located on the same supply pole</td>
<td>a) Top of Customer’s service mast; or b) Customer’s disconnect enclosure</td>
<td>- Unmetered Basic Connection Charge collected directly from the Customer ($446.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>(2) Source connection is made at Distributor’s supply pole (or lines), and the service mast is not located on the same supply pole</td>
<td>a) Top of Customer’s service mast; or b) Customer’s disconnect enclosure</td>
<td>- Unmetered Basic Connection Charge collected directly from the Customer ($1011.00)</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td><strong>Underground Supply:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Customer attachments on Distributor’s poles</td>
<td>Line side of Customer’s circuit breaker panel on pole</td>
<td>- Actual connection costs collected directly from the Customer</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
<tr>
<td>(2) Customer attachments not on Distributor’s poles</td>
<td>Customer’s disconnect enclosure at Customer’s structure</td>
<td>- Actual connection costs collected directly from the Customer</td>
<td>(Variable Disconnection Charge collected directly from the Customer)</td>
</tr>
</tbody>
</table>

(*) Typical connection costs by Class of Customers are available upon request.
### TABLE 3  New or Upgraded Street Lighting Services – Point of Demarcation and Connection Charges

<table>
<thead>
<tr>
<th>Types of Street Lighting, Distribution Systems</th>
<th>Ownership Demarcation Point</th>
<th>Standard Allowance</th>
<th>Basic Connection Fee (subject to annual review)</th>
<th>Variable Connection Fee(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Lights attached to Distributor’s poles and connected to Distributor's overhead 120/240 V secondary bus.</td>
<td>Connections at the overhead bus.</td>
<td>Connections made at Distributor's overhead secondary bus.</td>
<td>$533.36</td>
<td>Customer charged actual costs for connection assets above and beyond the Standard Allowance.</td>
</tr>
<tr>
<td>Municipal Lights attached to Distributor’s poles (in mixed use urban setting)** and connected to Distributor's underground 120/240 V secondary bus.</td>
<td>At the base of the Street Lighting bracket connected to the pole.</td>
<td>Connections made in the pole's handhole.</td>
<td>$573.97</td>
<td>Customer charged actual costs for connection assets above and beyond the Standard Allowance. (e.g. cable chamber/tap box breakout, underground conduit and cables, additional connections)</td>
</tr>
<tr>
<td>Municipal Lights attached to Municipality's poles (in residential setting) and connected to Distributor's underground 120/240 V secondary bus.</td>
<td>Line side of the protective device (i.e. circuit breaker, fuse) in the pole's handhole.</td>
<td>Connections made in the pole's handhole.</td>
<td>$573.97</td>
<td>Customer charged actual costs for connection assets above and beyond the Standard Allowance. (e.g. cable chamber/tap box breakout, underground conduit and cables, additional connections)</td>
</tr>
</tbody>
</table>

*Consulting and engineering work is not included and may be separately charged.

** mixed use urban setting, where streets are classified as Collector or Arterial.
### TABLE 4  Customer-Owned Transformers (Article 3.4.1)

<table>
<thead>
<tr>
<th>Transformer Voltage</th>
<th>Recommended Primary Tap Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+5%</td>
</tr>
<tr>
<td>27600 grd.Y/16000</td>
<td>28980</td>
</tr>
<tr>
<td>less than 750</td>
<td></td>
</tr>
<tr>
<td>27600 grd.Y/16000</td>
<td>28290</td>
</tr>
<tr>
<td>13800 grd.Y/8000</td>
<td></td>
</tr>
<tr>
<td>27600 2400/4160 Y</td>
<td>28290</td>
</tr>
<tr>
<td>13860 2400/4160 Y</td>
<td>14206</td>
</tr>
<tr>
<td>less than 750</td>
<td></td>
</tr>
<tr>
<td>13860 13860 grd.Y/8000</td>
<td>14553</td>
</tr>
</tbody>
</table>
### TABLE 5 Meter Sockets (Article 2.3.7.1.2)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Phase</th>
<th>Wire</th>
<th>Maximum Service Switch Size Rating Amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/240</td>
<td>1</td>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>120/240</td>
<td>1</td>
<td>3</td>
<td>400 *</td>
</tr>
<tr>
<td>208/120</td>
<td>2</td>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>208/120</td>
<td>3</td>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>600/347</td>
<td>3</td>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>600 **</td>
<td>3</td>
<td>3</td>
<td>200</td>
</tr>
</tbody>
</table>

* A 400 amp transformer-rated meter socket contains a 3 wire current transformer and transformer type meter. Refer to Section 6, Reference #6 – “Toronto Hydro Metering Requirements 750 Volts or Less” Table I, for a list of manufacturer’s meter sockets approved by Toronto Hydro.

** Used only for existing services where grounded supply is not available.

** Notes:**

1. Only CSA approved meter sockets are to be used.

2. Meter sockets shall be mounted so that the midpoint of the meter is set at 1700 mm ± 100 mm.

3. Where the supply is grounded, 600 V metering shall be 4 wire. Where the Customer does not require a neutral, a full size neutral conductor sized in accordance with Table 16 of the Ontario Electrical Safety Code must be provided to all meter cabinets or sockets. The neutral conductor is to be terminated in the socket (or cabinet) on an insulated block in accordance with the Ontario Electrical Safety Code.
Section 5 – TABLES

TABLE 6  Meter Cabinets (Article 2.3.7.1.2)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Phase</th>
<th>Wire</th>
<th>Main Switch Size in Amperes</th>
<th>Meter Cabinets (see description below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/240</td>
<td>1</td>
<td>3</td>
<td>Over 400</td>
<td>A</td>
</tr>
<tr>
<td>208/120</td>
<td>3</td>
<td>4</td>
<td>Over 200 – 800</td>
<td>A</td>
</tr>
<tr>
<td>416/240</td>
<td></td>
<td></td>
<td>Over 800</td>
<td>B</td>
</tr>
<tr>
<td>600/347</td>
<td></td>
<td></td>
<td>Over 800</td>
<td>B</td>
</tr>
<tr>
<td>600*</td>
<td>3</td>
<td>3</td>
<td>Over 200 – 400</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over 800</td>
<td>B</td>
</tr>
</tbody>
</table>

* Only for existing services where grounded supply is not available.

**Meter Cabinet Descriptions**

A – 48” x 48” x 12” complete with removable 44” x 44” backplate.
B – 36” x 36” x 12” connected to switchgear instrument transformer compartment.

**Notes:**

1. Meter cabinets shall be fabricated of minimum # 16 gauge steel.

2. Cabinets shall have side-hinged doors opening at the center and be equipped with three-point latching and provision for padlocking.

3. The maximum distance from the floor to the top of the cabinet shall be 1830 mm.

4. Where two or more circuits are used in one meter cabinet, Toronto Hydro will issue specific metering requirements.
### TABLE 7 Instrument Transformers and Enclosures (Article 2.3.7.2)

<table>
<thead>
<tr>
<th>Voltage (Volts)</th>
<th>Phase</th>
<th>Wire</th>
<th>Service Size (Amperes)</th>
<th>Compartmen Size</th>
<th>Number of Metering Transformers (Provision for)</th>
<th>Current</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>240/120 208/120 N/W</td>
<td>1</td>
<td>3</td>
<td>Up to 800</td>
<td>A</td>
<td>1 or 2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>Over 800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Up to 4000</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>208 / 120 416 / 240 600 / 347</td>
<td>3</td>
<td>4</td>
<td>Up to 800</td>
<td>A</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over 800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Up to 4000</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 (*)</td>
<td>3</td>
<td>3</td>
<td>Up to 800</td>
<td>A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over 800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Up to 4000</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltages up to 600</td>
<td>3 (*)</td>
<td>3 (*)</td>
<td>Over 4000</td>
<td>C</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Only for existing services where grounded supply is not available.

**MINIMUM COMPARTMENT SIZES** [width x height x depth (from CT mounting plate)]

- A - 762mm x 762mm x 210mm (30” x 30” x 8.25”)
- B - 915mm x 762mm x 324mm (36” x 30” x 12.75”)
- C - 965mm x 914mm x 381mm (38” x 36” x 15”)

**NOTES:**

1. Instrument transformers will be provided by Toronto Hydro and shall be installed in the switchgear by the manufacturer. The manufacturer shall not disassemble and/or change in any manner the Toronto Hydro equipment sent to the manufacturer.

2. Voltage transformer connections shall be connected on the line side of the current transformers. Current transformers shall be installed with their polarity marks towards the incoming Toronto Hydro supply.
Section 5 – TABLES

TABLE 8  Meter Centres (Article 2.3.7.1.2)

Meter centers may be used for 750 V applications or less, as far as they meet the following specifications:

1) Side-hinged doors or panels shall be installed over all sections of the switchboard where Toronto Hydro may be required to work, such as unmetered sections and those sections containing breakers, switches and meter mounting devices. Hinged doors or panels shall have provision for sealing and padlocking in the closed position. Where bolts are used, they shall be of the captive knurled type. The hinged covers over breakers or switches shall be so constructed that the covers cannot be opened when sealed or padlocked.

2) Breakers or switch handles shall have provision for positive sealing and padlocking in the “off” position.

3) Meter mounting devices shall be wired so as to be on the “load” side of the breakers or switches.

4) Each combination meter socket and breaker panel shall have adequate space for permanent Customer identification with respect to street address and/or unit number.

5) The centre of the bottom row of meter sockets shall be not less than 600 mm from the finished floor. The centre of the top row of meter sockets shall be not less than 1800 mm from the finished floor.

6) The distance between adjacent meter socket rims in the horizontal plane shall not be less than 152 mm.

7) The distance between adjacent meter socket rims in the vertical plane shall be as follows:
   a) For 100 A., 4 or 5 jaw, not less than 76 mm.
   b) For 100 A., 7 jaw, not less than 152 mm.

8) The meter mounting socket and sealing ring shall be acceptable to Toronto Hydro.

9) Where a neutral is required, the meter mounting device shall have a pre-wired, ungrounded neutral connection to the 5th or 7th terminal. The connection, if not made directly to the neutral bus, shall be not less than #12 AWG copper or equivalent.
TABLE 9.1 – Unmetered Scatter Load Process Map: Customer Connection / Transfer / Disconnection / Removal Services

<table>
<thead>
<tr>
<th>Unmetered Scattered Load – Process Map</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Connection / Transfer / Disconnection / Removal Services</strong></td>
</tr>
<tr>
<td><strong>Start</strong></td>
</tr>
<tr>
<td>Complete Application Form for Connection, Transfer, Disconnection, Removal</td>
</tr>
<tr>
<td>1A</td>
</tr>
<tr>
<td>Submit Application to Toronto Hydro (<a href="mailto:thunmeteredservices@torontohydro.com">thunmeteredservices@torontohydro.com</a>)</td>
</tr>
<tr>
<td>1B</td>
</tr>
<tr>
<td>Customer submits requested information and/or payments</td>
</tr>
<tr>
<td>1E</td>
</tr>
<tr>
<td>Notify Customer of any Outstanding Information and/or Payments Required</td>
</tr>
<tr>
<td>1F</td>
</tr>
<tr>
<td>Connect / Transfer / Disconnect / Remove - Customer Service Connection</td>
</tr>
<tr>
<td>1G</td>
</tr>
<tr>
<td>Forward Details to Billing and Record Management</td>
</tr>
<tr>
<td><strong>End</strong></td>
</tr>
<tr>
<td>Complete Application Form for Connection, Transfer, Disconnection, Removal</td>
</tr>
<tr>
<td>1D</td>
</tr>
<tr>
<td>Application Review</td>
</tr>
<tr>
<td>1C</td>
</tr>
<tr>
<td>Complete Design</td>
</tr>
<tr>
<td>1D</td>
</tr>
<tr>
<td>Customer Billing Cycle / Update Database</td>
</tr>
<tr>
<td>1H</td>
</tr>
<tr>
<td>• Add New</td>
</tr>
<tr>
<td>• Transfer</td>
</tr>
<tr>
<td>• Disconnection</td>
</tr>
<tr>
<td>• Removal</td>
</tr>
<tr>
<td>3A</td>
</tr>
</tbody>
</table>

**Toronto Hydro (TH)**
### TABLE 9.2 – Toronto Hydro / Customer Interactions for Table 9.1 Process Map: Customer Connection/Transfer/Disconnection/Removal Services

<table>
<thead>
<tr>
<th>Refer to Table 9.1</th>
<th>Description</th>
</tr>
</thead>
</table>
| **1A** Customer    | Clarifications with regards to Application Form requirements can be directed to thunmeteredservices@torontohydro.com.  
|                    | Fill out the Application Form complete with all required information and documentation for a new connection, transfer or disconnection of services. |
| **1A** Toronto Hydro | Toronto Hydro requires a completed Application Form including load in order to process the Customers requested service.  
|                    | Make available to the Customer, the Application Form and contact information for application support. |
| **1B** Customer    | Submit an Application Form complete with all required information and documentation to thunmeteredservices@torontohydro.com.  
|                    | Information submitted shall be an accurate representation of the unmetered connection. |
| **1B** Toronto Hydro | Acknowledge receipt of Application Form. |
| **1C** Customer    | To receive acknowledgement of receipt of Application Form.  
|                    | Provide any additional information that Toronto Hydro may request. |
| **1C** Toronto Hydro | Toronto Hydro shall not proceed with the Customer’s request unless the Application Form is complete and accurate.  
|                    | Review submitted Application Form for completeness.  
|                    | Notify Customer of any additional requirements to complete the Application Form. |
| **1D** Customer    | Provide any additional information that Toronto Hydro may request.  
|                    | Should Toronto Hydro deny the Customer’s request, the Customer will be provided with a reason for denial in writing. |
| **1D** Toronto Hydro | Toronto Hydro will make every effort to accommodate the Customer’s request; however there may be incidences where the Customer’s request may be denied.  
|                    | Complete design and installation review.  
|                    | Discuss issues with Customer which may transpire. |
### TABLE 9.2 – Toronto Hydro / Customer Interactions for Table 9.1 Process Map: Customer Connection/Transfer/Disconnection/Removal Services (continued)

<table>
<thead>
<tr>
<th>Rights and Obligations</th>
<th>Refer to Table 9.1</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1E</td>
<td><strong>Customer</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Acknowledgment of receipt.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provide any outstanding information and/or payments required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Toronto Hydro</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Notify the Customer of any outstanding information and/or payments required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refuse connection if any of the requirements are not met.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Once the requested information is received and approved by Toronto Hydro and payment is received and processed, Toronto Hydro will proceed with the Service request.</td>
</tr>
<tr>
<td></td>
<td>1F</td>
<td><strong>Customer</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Customer shall perform any work that is the responsibility of the Customer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Customer shall comply with all of the requirements of Toronto Hydro’s Conditions of Service, Toronto Hydro Construction Standards, and the Ontario Electrical Safety Code to ensure public safety in performing the work.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Toronto Hydro</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Toronto Hydro shall perform any work that is the responsibility of Toronto Hydro.</td>
</tr>
<tr>
<td></td>
<td>1G</td>
<td><strong>Toronto Hydro</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• After completion of all work Service information is sent for billing processing.</td>
</tr>
<tr>
<td></td>
<td>1H</td>
<td><strong>Customer</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To receive acknowledgement from Toronto Hydro that the Service request has been completed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Toronto Hydro</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Toronto Hydro will notify Customer that the Service request has been completed.</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td><strong>Toronto Hydro</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Create, remove, or modify a Customer’s Service in accordance to the work completed for the Customer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Update billing system and cycle to reflect updates to a Customer’s Service.</td>
</tr>
</tbody>
</table>
### TABLE 9.3 – Unmetered Scatter Load Process Map: Existing Customer Service Updates and Validation

**Unmetered Scattered Load – Process Map**

<table>
<thead>
<tr>
<th>Customer</th>
<th></th>
<th>Toronto Hydro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>Initiate Data Update</td>
<td>Start</td>
</tr>
<tr>
<td>2A</td>
<td>Submit Updated Data to Toronto Hydro (<a href="mailto:thunmeteredservices@torontohydro.com">thunmeteredservices@torontohydro.com</a>)</td>
<td>Initiate Data Update</td>
</tr>
<tr>
<td>2B</td>
<td>Validate Data</td>
<td>2D</td>
</tr>
<tr>
<td>2C</td>
<td>Update Billing/Database</td>
<td>3A</td>
</tr>
<tr>
<td>2D</td>
<td>End</td>
<td></td>
</tr>
</tbody>
</table>

---

**Existing Customer Service Updates and Validation**
**TABLE 9.4 – Toronto Hydro / Customer Interactions for Table 9.3 Process Map: Existing Customer Service Updates and Validation**

<table>
<thead>
<tr>
<th>Refer to Table 9.3</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Updating and Validation Process</strong></td>
<td></td>
</tr>
</tbody>
</table>
| 2A Customer | Customer to provide a complete data update on a regular interval basis.  
Customer to provide a data update immediately upon any Customer changes. |
| 2B Customer | Upon request by Toronto Hydro, the Customer shall provide a data update. Requested data update may include details such as the precise location, service size, load profiles, and account information.  
**Toronto Hydro**  
In addition, Toronto Hydro may require the Customer to provide a data update at any time. |
| 2C Customer | Data updates shall be provided in a format acceptable to Toronto Hydro.  
Data updates shall be submitted to Toronto Hydro.  
A Customer Load Accuracy Declaration shall be submitted with any data update submitted by the Customer. |
| 2D Customer | Provide any additional information that Toronto Hydro may request. This may include field audits and Customer’s work documentation to support changes and validation.  
**Toronto Hydro**  
Any updated data will be reviewed for accuracy and completeness.  
Notify Customer of any additional information required or audit requirements in order to complete the updated data review.  
Periodical audits of existing Customer accounts to validate the data accuracy.  
Perform audits which may include field audits, and/or on-site measurements of unmetered accounts to validate the data provided by the Customer. |
| **Billing Update Process** | |
| 3A Toronto Hydro | Update its records based on the information received from the Customer subject to verification through a validation process.  
Toronto Hydro will inform the Customer of any changes to their account in writing. |
Section 6 – REFERENCES

6 REFERENCES

1. Economic Evaluation Model for Distribution System Expansion
   Refer to Appendix B of the Distribution System Code:
   "Methodology and Assumptions for an Economic Evaluation"

2. Standard Toronto Hydro Connection Agreements - Terms of Conditions
   • Schedule A:
     • Toronto Hydro-Electric System Limited Connection Agreement

3. Toronto Hydro Distributed Generation Requirements

4. Toronto Hydro Requirements for the Design and Construction of Customer-Owned High Voltage Substations

5. Toronto Hydro Requirements for the Design and Construction of Customer-Owned Structures

6. Toronto Hydro Metering Requirements 750 Volts or Less

7. Toronto Hydro Metering Requirements for 13.8 kV & 27.6 kV Customer-Owned Substations

8. Contractor Pre-Qualification Application

9. Toronto Hydro Metering Services and Charges
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
(“BOMA”) INTERROGATORIES

INTERROGATORY 76:

Reference(s): Exhibit 2B, Section E5, p. 17

Why does Table 9, p14 data exceed the 2020-2024 planned CCS?

RESPONSE:

Please see Toronto Hydro’s response to interrogatory 2B-BOMA-74.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 77:
Reference(s): Exhibit 2B, Section E5, p. 21

What are the forecast savings for the combination of low and high voltage design teams at the expanded CRM system?

RESPONSE:
The question references two distinct and separate productivity improvements made by Toronto Hydro during the 2015 to 2019 period:

- In respect of the CRM system, this allows Toronto Hydro to effectively manage timelines associated with connection requests and provide historical records. This translates into more robust reporting on the status of projects, with less time being spent on generating the reports, and better storage of historical records, with less time being spent on locating information pertaining to old projects. Please refer to Toronto Hydro’s response to interrogatory 4A-Staff-114 (b) for further discussion of the CRM system.

- In respect of the merger of two of Toronto Hydro’s design groups (low voltage and high voltage), this has provided Toronto Hydro with the flexibility to absorb the fluctuation and seasonality in the low voltage type requests (Exhibit 4A, Tab2, Schedule 8, Figure 1) by utilizing and re-directing the design resources of that portfolio to ensure high voltage projects are completed in a timely manner to meet the customer needs. In essence this allows for a single team to oversee all of the incoming requests and all of the design staff to balance the workload more
effectively. Low voltage requests typically deal with residential and small commercial services and developments (which typically require a quick turnaround) while the high voltage work flow deals with larger residential, typically new condos, and larger industrial/commercial developments that can take years to materialize.

Direct tangible savings are difficult to forecast as these productivity enhancements are not focused on cost savings but rather have allowed Toronto Hydro to effectively balance labour demand to available capacity and improve customer communications and project tracking from inception to energization.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 78:
Reference(s): Exhibit 2B, Section E5, p. 23

What are the criteria for allowances of an alternative bid? Please provide copies of sample OTC's to demonstrate same.

Please provide a list of each proposed request for a road authority or another agency, already filed or anticipated for each of 2020 and 2021. For each project, please estimate the share THESL will seek to recover from the RA or agency.

RESPONSE:
Please refer to the following for the criteria for alternative bid allowances:

- Toronto Hydro’s Condition of Service – Section 2.1.2.1; and
- Distribution System Code – Clause 3.2.15, 3.2.15A, and 3.1.15B

Please see attached Appendix A for a template OTC.

Please refer to Exhibit 2B, Section E5.2.4 for a list of proposed requests from road authorities and other agencies and the share Toronto Hydro seeks to recover.
[Date] OTC #:

[Customer’s Full Legal Name]
[Customer’s Address]

Attention: [Contact Person]

Dear Sir/Madam:

Re: OFFER TO CONNECT

[Customer’s Name] development of [municipal address] 
as legally described in PIN [*] (“Property”)

Toronto Hydro Customer Class [3C] [3C multi-phase] [4] [5]

Toronto Hydro Project No. * Work Order No. * (“Project”)

Customer’s Request for Connection

Toronto Hydro-Electric System Limited (“Toronto Hydro”) has received [Customer]’s (“Customer”) written request for connection of the Project to the Toronto Hydro main distribution system.

[Select all that is applicable, delete others]

- [#] residential units will be constructed and will need to be connected to the Toronto Hydro main distribution system; [AND/OR]
- the Customer [will select][will not be selecting] Toronto Hydro as its suite metering provider and will require [#] of suite meters and [#] of bulk interval meters to be installed; [AND/OR]
- [#] of general service metering connection(s) will be constructed and connected to the Toronto Hydro main distribution system; [AND/OR]
- [#] of Municipal Unmetered Street Lighting connection(s) will be constructed and connected to the Toronto Hydro main distribution system; [AND/OR]
- [#] of unmetered connection(s) will be constructed and connected to the Toronto Hydro main distribution system; [AND/OR]
- the Estimated Incremental Demand load attributable to the Project will be [***] kVA. [The Residential Portion of the Project consisting of an Estimated Incremental Demand load of [***] KVA; and the Commercial and Industrial Portion of the Project consisting of an Estimated Incremental Demand load of [***] KVA.]

Toronto Hydro will provide service to the Customer during the Realization Period based upon the Estimated Incremental Demand attributable to the Project. However, unused capacity will not be reserved past the Realization Period. After the Realization Period Toronto Hydro reserves the right to examine the Customer’s actual demand with a view to optimizing its feeder capacity. If the actual demand is lower than the Estimated Incremental Demand, then Toronto Hydro will adjust downwards its internal demand forecast for the Customer, and may re-assign any unused capacity if it determines this is appropriate to meet other demand needs. For feeder(s) which have been dedicated to supply electricity for the sole use of a Customer, then the re-assignment of any unused capacity will not be applied.

The Customer agrees that the demand load shall not be exceeded. If circumstances exist that the Customer must realize an increase in the contracted demand load, the Customer shall notify Toronto Hydro in writing of the intent to increase the demand load, and request Toronto Hydro’s approval prior to
affecting any such increases. Customer requests for increased demand load shall be processed through a new offer to connect.

In order to connect the Project, an expansion to the Toronto Hydro main distribution system will be needed.

**Toronto Hydro’s Offer to Connect**

Based on the plans dated [***]. Toronto Hydro has prepared this document. This document, including all Schedules attached, is Toronto Hydro’s firm Offer to Connect as required by the Distribution System Code established by the Ontario Energy Board.

In addition to the obligations set forth in this Offer to Connect, the Customer shall be bound by and required to comply with all provisions of Toronto Hydro’s Conditions of Service as amended from time to time. A copy of the Conditions of Service can be obtained at <www.torontohydro.com>.

[Under section 2.3.7.1.1 of Toronto Hydro’s Conditions of Service, the Customer may choose to have Toronto Hydro install smart suite metering, or to have Toronto Hydro install a bulk interval meter for the purpose of enabling smart sub-metering by a licensed sub-metering service provider.]

This Offer to Connect has been prepared on the basis of [individual metering by Toronto Hydro.] / smart sub-metering by an alternative licensed service provider.]

[If the Customer chooses individual metering by Toronto Hydro, add the following:

This Offer to Connect has been prepared on the basis of individual metering by Toronto Hydro. It is a condition of this Offer to Connect that the Customer enter into a Suite Metering Agreement with Toronto Hydro. The Customer represents and warrants that it [has signed / will sign] a Suite Metering Agreement with Toronto Hydro.]

The Electricity Act, 1998 requires that all buildings receiving electricity from Toronto Hydro be directly connected to the distribution grid. A Customer-Owned substation or Customer-Owned equipment installed on the load side of Toronto Hydro owned transformation facilities, may only provide electricity to building(s) owned by that Customer. Thus the Customer cannot provide electricity to building(s) owned by another Customer. If at any time, any building changes ownership such that a Customer-Owned substation or Customer-Owned equipment installed on the load side of Toronto Hydro owned transformation facilities provides electricity to another Customer, Toronto Hydro will require that the building incurring the ownership change (the “New Owner”) pay for ALL costs associated with reconfiguring its electricity supply so that it is directly connected to Toronto Hydro’s distribution grid (and not via another Customer). Failure to pay these costs may result in disconnection of the New Owner.

The following attached Schedules form a part of this Offer to Connect:

- SCHEDULE A – Definitions and Overview
- SCHEDULE B – Connection Work and Expansion Work
- SCHEDULE C – Connection Costs and Expansion Costs
- SCHEDULE D – Capital Contribution and Expansion Deposit
- SCHEDULE E – Future Rebates and Recent Expansions
- SCHEDULE F – Alternative Bid Process
- SCHEDULE G – General Terms & Conditions
- SCHEDULE H – The Economic Evaluation
### Summary of Required Costs, Contributions, and Deposits

The Customer shall provide the TOTAL PAYMENT, which is non-refundable, and the TOTAL DEPOSIT contained in the following table to Toronto Hydro for the connection of the Project:

<table>
<thead>
<tr>
<th></th>
<th>If Customer is not pursuing an Alternative Bid:</th>
<th>If Customer is pursuing an Alternative Bid:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Toronto Hydro to undertake work)</td>
<td>(Toronto Hydro to only undertake work that is ineligible for Alternative Bid):</td>
</tr>
<tr>
<td><strong>Connection Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Balance Outstanding)</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>(from Schedule C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capital Contribution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(from Schedule D)</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td><strong>Expansion Deposit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(from Schedule D)</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td><strong>Additional Alternative Bid Costs</strong></td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td>(from Schedule C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Payment for Recent Expansion Benefits</strong></td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td>(from Schedule E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL PAYMENT REQUIRED</strong></td>
<td>[Sum of the above excluding Expansion Deposit]</td>
<td>[Sum of the above excluding Expansion Deposit and Capital Contribution]</td>
</tr>
<tr>
<td><strong>TOTAL DEPOSIT REQUIRED</strong></td>
<td>[Amount of Expansion Deposit]</td>
<td>[Amount of Expansion Deposit]</td>
</tr>
</tbody>
</table>

NOTE: All amounts include HST.

Based on the plans and information provided to Toronto Hydro, as of the date of this Offer to Connect, an easement [will be required to connect the Project.] OR [will not be required to connect the Project, but may be required if the information, plans or design of the Project changes.]

General easement requirements are set out under the heading “Easements” in SCHEDULE G, General Terms & Conditions.

If the terms and conditions of this Offer to Connect are acceptable to the Customer, a duly authorized officer of the Customer shall sign a duplicate copy and return it along with all payments and deposits to Toronto Hydro within 60 days of the date the Offer to Connect is issued to the Customer. If a signed copy of the Offer to Connect and all payments and deposits are not returned to Toronto Hydro within that time period, Toronto Hydro reserves the right to revoke this Offer to Connect without further notice to the Customer. The Customer is advised that Toronto Hydro requires a minimum of [***] weeks, if not more lead time to complete the Project, after receiving the signed Offer to Connect and all payments and deposits from the Customer. The Customer should make arrangements to return the signed Offer to Connect and all payments and deposits early to accommodate the required lead time.

If the Expansion Work for this Project, as defined in Schedule B, has not commenced within one (1) year from the date set forth above, Toronto Hydro has the right to terminate this Offer to Connect in accordance with its rights of termination as set out herein.
If the Offer to Connect needs to be revised after it is issued to the Customer due to information provided by the Customer that is different from what the Customer initially provided to Toronto Hydro, the Customer shall pay a revision fee to Toronto Hydro to prepare and issue the revised Offer to Connect.

Any notice, communication and inquiry regarding this Offer to Connect must be directed as follows:

To: Toronto Hydro-Electric System Limited  
500 Commissioners Street  
Toronto, Ontario, M4M 3N7  
Attention: Kunal Ajmani, P.Eng., MBA  
Supervisor, Engineering & Construction Policy  
Telephone: (416) 542-3100 ext 32204  
Email: kajmani@torontohydro.com

To: The Customer at the address set forth below:  
*  
Company Name:  
Attention: *  
Telephone: (*), Facsimile: (*)  
Email: *

Unless otherwise noted in this Offer to Connect, all payments and security required are due and payable, or deliverable, upon acceptance of this Offer to Connect by the Customer.

Please sign in the two appropriate places below (i.e., sign below and either (1A) or (1B)) and return one signed copy, together with all payments, deposits, and security as may be required, to:

To: Toronto Hydro-Electric System Limited  
Legal Services Division  
14 Carlton Street  
Toronto, Ontario, M5B 1K5  
Attention: Helen Tseng  
Telephone: (416) 542-3368

Yours truly,

Toronto Hydro-Electric System Limited

Per: _____________________________  
Name: Dino Priore, P.Eng., MBA  
Title: Executive Vice-President and Chief Engineering and Construction Officer

I have authority to bind the Corporation.
[Customer] acknowledges its understanding of, accepts, agrees to comply with, and be bound by, all of the terms and conditions of this Offer to Connect, which include the provisions set forth above and all of the Schedules attached. The Customer acknowledges that upon accepting this Offer to Connect, a binding and legally valid agreement is created that is enforceable at law in accordance with its terms.

| Company Name: | Date: __________________________ |-|  
| Per: __________________________ |  
| Name: |  
| Title: |  
| I have authority to bind the Corporation. |  

In addition, [Customer] confirms that it:

<table>
<thead>
<tr>
<th>(1A) will not be pursuing an Alternative Bid for the work that is Eligible for Alternative Bid as described in Schedules B and F.</th>
<th>OR (1B) will be proceeding by way of an Alternative Bid for the work that is Eligible for Alternative Bid as described in Schedules B and F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Name:</td>
<td>Company Name:</td>
</tr>
<tr>
<td>Per: __________________________</td>
<td>Per: __________________________</td>
</tr>
<tr>
<td>Name:</td>
<td>Name:</td>
</tr>
<tr>
<td>Title:</td>
<td>Title:</td>
</tr>
<tr>
<td>I have authority to bind the Corporation.</td>
<td>I have authority to bind the Corporation.</td>
</tr>
</tbody>
</table>

| Date: __________________________ | Date: __________________________ |

Draft Offer to Connect [Customer] [Address of Project] [Date]
SCHEDULE A
DEFINITIONS and OVERVIEW

1. This Offer to Connect, including all of its schedules, was developed in accordance with the Ontario Energy Board’s Distribution System Code and Toronto Hydro’s Conditions of Service.

2. Terms used in this Offer to Connect have the meanings provided in the Distribution System Code and the Conditions of Service unless otherwise defined. Terms that are defined are to be interpreted expansively and in harmony with the Ontario Energy Board’s Distribution System Code.

3. The following is a list of the most common terms found in this Offer to Connect together with their respective meanings. (Terms that are not as common are defined directly in the cover letter or schedule that they first appear in.)

(i) **Alternative Bid** is the process that includes a Customer obtaining and using a [Qualified Contractor](#) to complete [Connection Work](#) and [Expansion Work](#) that is eligible to be completed by a contractor as an alternative to Toronto Hydro.

(ii) **Additional Alternative Bid Costs** are the costs to provide the [Additional Alternative Bid Work](#) that will be required if the Customer pursues an [Alternative Bid](#).

(iii) **Additional Alternative Bid Work** is work that Toronto Hydro must undertake if the Customer pursues an [Alternative Bid](#), and includes, but is not limited to:

   (a) any additional design, engineering, or installation work;
   
   (b) any temporary de-energization of any portion of the existing distribution system that is required to accommodate the work performed by the contractor hired by the Customer;
   
   (c) administering the contract between the Customer and the contractor hired by the Customer if Toronto Hydro is asked to administer the contract by the Customer and Toronto Hydro agrees to administer the contract;
   
   (d) inspection or approval of the work performed by the Customer’s contractor hired by the Customer.

(iv) **Basic Connection Costs** are standard costs that are defined in Section 5 of Toronto Hydro’s Conditions of Service.

(v) **Capital Contribution** is the difference between the present value of the [Expansion Costs](#), [Basic Connection Costs](#), [OM&A Costs](#), including tax considerations, and the present value of the [Incremental Revenues](#). The **Capital Contribution** is determined by Toronto Hydro using the economic evaluation contained in **SCHEDULE H**.

(vi) **Connection Assets** are the assets between the point of connection to the Toronto Hydro main distribution system and the ownership demarcation point as defined in Section 5 of Toronto Hydro’s Conditions of Service.

(vii) **Connection Costs** are the total costs to provide the [Connection Assets](#) and complete the [Connection Work](#). [Connection Costs](#) are made up of the sum of the [Basic Connection Costs](#) and the [Variable Connection Costs](#).

(viii) **Connection Work** is the work required to construct the [Connection Assets](#).

(ix) **Customer** means a person that has contracted for or intends to contract for connection of a building. This includes, but is not limited to, developers of residential or commercial sub-divisions.
(x) **Distribution System Code** means the code, approved by the Ontario Energy Board and in effect at the relevant time, which, among other things, establishes the obligations of a distributor with respect to the services and terms of service to be offered to customers and retailers and provides minimum technical operating standards of distribution systems.

(xi) **Distributor** means a person who owns or operates a distribution system.

(xii) **Eligible Alternative Bid Work** means an Alternative Bid to complete the **Connection Work** and **Expansion Work** identified as Eligible for Alternative Bid in SCHEDULE B.

(xiii) **Estimated Incremental Demand** is the increased demand load attributable to the Project.

(xiv) **Expansion** means a modification or addition to the main distribution system in response to one or more requests for one or more additional customer connections that otherwise could not be made, for example, by increasing the length of the main distribution system, and includes the modifications or additions to the main distribution system identified in section 3.2.30 of the Distribution System Code.

(xv) **Expansion Assets** are the assets that will form the modifications and additions to Toronto Hydro’s main distribution system when the Expansion Work is completed.

(xvi) **Expansion Costs** are the costs to provide the Expansion Assets and to complete the Expansion Work.

(xvii) **Expansion Deposit** is the difference between the total Ineligible and Eligible Expansion Costs and HST and the amount of the Capital Contribution and HST.

(xviii) **Expansion Work** is the work required to modify or add to Toronto Hydro’s main distribution system such that the Project can be connected and supplied with electricity.

(xix) **Final Economic Evaluation** means the final economic evaluation performed by Toronto Hydro after the Eligible for Alternative Bid, Expansion Assets are energized.

(xx) **Future Customer** means any other customer that connects to the Toronto Hydro distribution system within five (5) years of the energization date of the Expansion Assets.

(xxi) **Incremental Revenues** are the distribution revenues, attributable to the Project, which will be received by Toronto Hydro after the Project is connected.

(xxii) **Initial Economic Evaluation** means the economic evaluation that Toronto Hydro performs pursuant to the Ontario Energy Board’s Distribution System Code to determine the Capital Contribution.

(xxiii) **Offer to Connect** is this agreement including all Schedules attached.

(xxiv) **OM&A Costs** are the operating, maintenance and administration costs, including applicable taxes, associated with the Expansion Assets.

(xxv) **Other Customer** means another customer.

(xxvi) **Payment for Recent Expansion Benefits** is a payment made by the Customer to Toronto Hydro if the Customer is connecting to the Toronto Hydro distribution system and:
(a) The Customer will derive a benefit from assets that were constructed as part of Recent Expansion Assets to connect the Other Customer;
(b) The Customer’s connection was not anticipated and was not considered as part of the economic evaluation that was conducted for the Other Customer’s project; and
(c) The Customer will begin deriving a benefit within five (5) years of the energization date of the Recent Expansion Assets.

(xxvii) Project is the development described in the Re: line on Page 1 of this Offer to Connect requiring an expansion to the Toronto Hydro main distribution system.

(xxviii) Qualified Contractor is a contractor that has:
(a) submitted a “Contractor Pre-Qualification Application” to Toronto Hydro in accordance with Toronto Hydro’s Conditions of Service;
(b) demonstrated to Toronto Hydro the necessary minimum technical, financial and managerial competence to execute the work that is Eligible for Alternative Bid; and
(c) has been approved by Toronto Hydro to execute the work no less than 30 business days prior to being selected by the Customer to undertake work.

(xxix) Realization Period for a Project means the period ending upon the first to occur of:
[For residential developments]
(a) The materialization of the last forecasted connection, or
(b) Five (5) years after energization of the Expansion Assets.
[OR] [For commercial and industrial developments]
(a) The materialization of the last forecasted demand, or
(b) Five (5) years after energization of the Expansion Assets.
[OR] [For residential units combined with commercial and industrial developments]
(a) The materialization of both the last forecasted connection and last forecasted demand, or
(b) Five (5) years after energization of the Expansion Assets.

(xxx) Recent Expansion Asset means assets that were constructed as part of a recent expansion project.

(xxxi) Toronto Hydro means Toronto Hydro-Electric System Limited.

(xxii) Transfer Price means the price paid by Toronto Hydro to the Customer once Toronto Hydro has assumed ownership of all Eligible for Alternative Bid, Expansion Assets.

(xxxiii) Variable Connection Costs are the difference between the Connection Costs and the Basic Connection Costs.

4. SCHEDULE B contains and divides the work that is required to connect the Project into (i) Connection Work and (ii) Expansion Work. Connection Work and Expansion Work are further sub-divided under two categories. One category is for work that must be done by Toronto Hydro (“Ineligible for Alternative Bid” work) and the other category is for work that may be undertaken by the Customer using a Qualified Contractor (“Eligible for Alternative Bid” work). (iii) Additional Alternative Bid Work which is work that Toronto Hydro must undertake if the Customer pursues an Alternative Bid.

5. SCHEDULE C contains:
(i) **Connection Costs** that the Customer shall pay to Toronto Hydro;
(ii) **Expansion Costs** that Toronto Hydro shall recover through the **Capital Contribution** and **Incremental Revenues**; and
(iii) **Additional Alternative Bid Costs** that the Customer shall pay to Toronto Hydro if the Customer elects to pursue an **Alternative Bid**.

6. SCHEDULE D contains the **Capital Contribution** and the **Expansion Deposit** that the Customer shall provide to Toronto Hydro.

7. SCHEDULE E contains information about a rebate(s) to the **Capital Contribution** that the Customer may receive in the future and any payment that the Customer may need to make as consideration for benefits to be received from work that was recently undertaken as part of another customer’s connection to the Toronto Hydro distribution system.

8. SCHEDULE F contains important information and obligations pertaining to **Alternative Bids**. If the Customer elects to pursue an **Alternative Bid** for the **Eligible for Alternative Bid** work, then the Customer shall be bound by the provisions in SCHEDULE F.

9. SCHEDULE G contains general terms and conditions that apply to this Offer to Connect.

10. SCHEDULE H contains the economic evaluation that was conducted to determine the **Capital Contribution**.
SCHEDULE B
CONNECTION WORK and EXPANSION WORK

1. **Connection Work, Expansion Work** and **Additional Alternative Bid Work** that is required to connect and supply electricity to the Project are described in the table below.

2. **Connection Work** and **Expansion Work** for the Project may be divided into:
   (i) work that must be done by Toronto Hydro (**Ineligible for Alternative Bid** work); and
   (ii) work that the Customer may hire a **Qualified Contractor** to perform (**Eligible for Alternative Bid** work).

3. If the **Customer** hires a **Qualified Contractor** to perform **Eligible for Alternative Bid** work, then Toronto Hydro will need to undertake **Additional Alternative Bid Work**, which is described in the table below.

<table>
<thead>
<tr>
<th>Category of Work</th>
<th>Description of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Connection Work</td>
<td></td>
</tr>
</tbody>
</table>
| (a) Ineligible for Alternative Bid | - All necessary engineering design and inspections
- [insert description of Ineligible Alternative Bid Connection Work]
- [insert description of City cut permits and cut permit work related to Connection Asset that Toronto Hydro will undertake.]

**NOTE:** The Customer is responsible for:
- [insert description of work Customer is responsible for.]

<table>
<thead>
<tr>
<th>(b) Eligible for Alternative Bid</th>
<th>[insert description of Eligible Alternative Bid Connection Work]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>(ii) Expansion Work</th>
<th></th>
</tr>
</thead>
</table>
| (a) Ineligible for Alternative Bid | - All necessary engineering design and inspections;
- [insert description of Ineligible Alternative Bid Expansion Work e.g. physical contact with existing distribution system, work to be completed outside of Toronto Hydro’s safe limits of approach to energized facilities or equipment, dedicated replacement work]
- [insert description of City cut permits and cut permit work related to Connection Asset that Toronto Hydro will undertake.]

| (b) Eligible for Alternative Bid | [insert description of Eligible Alternative Bid Expansion Work] |

**Please note that:**
- All materials supplied by the Customer must:
  - be purchased from approved Toronto Hydro vendors;
  - be submitted to Toronto Hydro’s QAQC inspection contractor for approval prior to installation; and
  - meet Toronto Hydro Distribution Construction Standards;
- All equipment and underground plant must be installed to current Toronto Hydro construction standards and must be inspected and approved by Toronto Hydro’s QAQC inspection contractor prior to connection to the Toronto Hydro distribution system;

| (iii) Additional Alternative Bid Work | [insert description of Additional Alternative Bid Work] |
SCHEDULE C
CONNECTION COSTS and EXPANSION COSTS

1. Toronto Hydro shall recover **Connection Costs** through:
   (a) **Basic Connection Costs**, which are not collected directly from the Customer but are included in the economic evaluation contained in SCHEDULE H; and
   (b) **Variable Connection Costs**, which are collected directly from the Customer.

2. Toronto Hydro shall recover **Expansion Costs** as outlined in SCHEDULE D.

3. The Customer shall pay the balance outstanding for the **Ineligible and Eligible Connection Costs** to Toronto Hydro unless the Customer pursues an **Alternative Bid** in the manner described in SCHEDULE F, in which case the Customer shall:
   (i) pay to Toronto Hydro the balance outstanding for the **Ineligible for Alternative Bid Connection Costs** less any design prepayment received; and
   (ii) pay a **Qualified Contractor** to complete the **Eligible for Alternative Bid Connection Work** described in SCHEDULE B.

4. If the Customer pursues an **Alternative Bid**, the Customer shall pay the **Additional Alternative Bid Costs** to Toronto Hydro.

5. **Connection Costs**, **Expansion Costs**, and **Additional Alternative Bid Costs** for the Project are contained in the table below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Ineligible for Alternative Bid</th>
<th>Eligible for Alternative Bid</th>
<th>Ineligible and Eligible</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Connection Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUB-TOTAL</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Less Basic Connection Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($1,396 per meter connection)</td>
<td>$ -</td>
<td>Not Applicable</td>
<td>$ -</td>
</tr>
<tr>
<td>Variable Connection Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HST (13%)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Less Design Pre-Payment received</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BALANCE OUTSTANDING</td>
<td>$ -</td>
<td>Not Applicable</td>
<td>$ -</td>
</tr>
<tr>
<td>(ii) Expansion Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Labour (Design, Eng., &amp; Construction)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Equipment</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Overhead (including Administration)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>SUB-TOTAL</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>HST (13%)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>(iii) Additional Alternative Bid Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUB-TOTAL</td>
<td>$ -</td>
<td>$0</td>
<td>$ -</td>
</tr>
<tr>
<td>HST (13%)</td>
<td>$ -</td>
<td>$0</td>
<td>$ -</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$ -</td>
<td>$0</td>
<td>$ -</td>
</tr>
</tbody>
</table>

The costs contained in the table are based on work being done during non-winter conditions. If the Customer requires the work to be done during winter conditions that would result in additional costs, Toronto Hydro will advise
the Customer of the estimated additional costs and if the Customer provides a written request to Toronto Hydro to proceed, a Project Invoice will be issued and payment must be received by Toronto Hydro prior to the commencement of any of the applicable work.
SCHEDULE D
CAPITAL CONTRIBUTION and EXPANSION DEPOSIT

1. Toronto Hydro shall recover any Expansion Costs and OM&A Costs by way of:
   (i) a Capital Contribution, if applicable, paid by the Customer; and
   (ii) Incremental Revenues.

2. A summary of the Initial Economic Evaluation, including the assumptions and inputs used, is contained in SCHEDULE H.

3. The Customer acknowledges that for the purposes of enabling Toronto Hydro to perform the Initial Economic Evaluation and any subsequent economic evaluations, the Customer has represented to Toronto Hydro that:
   (i) [#] residential units will be constructed and will need to be connected to the Toronto Hydro main distribution system;
   (ii) the Customer [will select][will not be selecting] Toronto Hydro as its suite metering provider and will require [#] of suite meters and [#] of bulk meters to be installed; and
   (iii) [#] of general service metering connection(s) will be constructed and connected to the Toronto Hydro main distribution system; and
   (iv) the Estimated Incremental Demand will be [***] kVA;

[Delete any of the following sections that are not applicable and renumber accordingly]

OR [For Commercial projects Class 4, 5]

3. The Customer acknowledges that for the purposes of enabling Toronto Hydro to perform the Initial Economic Evaluation and any subsequent economic evaluations, the Customer has represented to Toronto Hydro that the Estimated Incremental Demand will be [***] kVA.

4. Given that the Capital Contribution only covers a portion of the Expansion Costs and OM&A Costs, and that the remainder is to be covered by Incremental Revenues made possible by the Project, there is a risk that Toronto Hydro will suffer a loss if the Estimated Incremental Demand or the forecasted number of connections does not materialize. To mitigate this risk, Toronto Hydro may request an Expansion Deposit from the Customer in the amount of the difference between the TOTAL Ineligible and Eligible Expansion Costs and HST and the amount of the Capital Contribution and HST.

5. The Expansion Deposit shall be in the form of cash, or an irrevocable commercial letter of credit issued by a Schedule 1 bank as defined in the Bank Act, or a surety bond. The form of security must expressly provide for its use to cover the events and time period for which it is held as a deposit. Any portion of the Expansion Deposit held as cash, which is returned to the Customer, shall include interest on the returned amount from the date of receipt of the full amount of the Expansion Deposit, at the Prime Business Rate set by the Bank of Canada less two (2) percent.

6. The Expansion Deposit is in addition to any other charges that may be payable to Toronto Hydro under this Offer to Connect, or the Conditions of Service, or otherwise.

[for residential units]

7. After the Expansion Assets have been constructed and energized, Toronto Hydro shall reduce the Expansion Deposit, at the end of each 365-day period, by an amount calculated by multiplying the original Expansion Deposit by a percentage derived by dividing the actual connections completed or materialized in that 365-day period, by the total number of connections.
contemplated in this Offer to Connect. For information about any reduction in the amount of the
Expansion Deposit, please contact Carrie George at (416) 542-3100 ext. 32076.

8. If after five (5) years from the energization date of the Expansion Assets, the total number of
connections contemplated by the original Offer to Connect have not materialized, Toronto Hydro
shall retain any cash held as an Expansion Deposit, or shall be entitled to realize on any letter of
credit or bond held as an Expansion Deposit and retain any cash resulting therefrom, with no
obligation to return any portion of such monies to the Customer at any time.

OR
[for commercial and industrial]
7. After the Expansion Assets have been constructed and energized, Toronto Hydro shall reduce
the Expansion Deposit, at the end of each 365-day period, by an amount calculated by
multiplying the original Expansion Deposit by a percentage derived by dividing the actual
demand materialized in that 365-day period, by the Estimated Incremental Demand
contemplated in this Offer to Connect. For information about reduction in the amount of the
Expansion Deposit after each 365 day period, please contact Carrie George at (416) 542-3100
ext. 32076.

8. If after five (5) years from the energization date of the Expansion Assets, the Estimated
Incremental Demand contemplated by this Offer to Connect has not materialized, Toronto Hydro
shall retain any cash held as an Expansion Deposit, or be entitled to realize on any letter of
credit or bond held as an Expansion Deposit and retain any cash resulting therefrom, with no
obligation to return any portion of such monies to the Customer at any time.

OR
[for residential units combined with commercial and industrial]
7. After the Expansion Assets have been constructed and energized, Toronto Hydro shall reduce
the Expansion Deposit, at the end of each 365-day period, by an amount calculated by:

   (i) For the residential connections: multiplying the portion of the original Expansion Deposit
       attributed to the residential connections (as determined by Toronto Hydro in its sole
discretion) by a percentage derived by dividing the actual connections completed or
materialized in that 365-day period, by the total number of connections contemplated in
this Offer to Connect;

   (ii) For the commercial or industrial load: multiplying the portion of the original Expansion
Deposit attributed to the commercial and industrial load (as determined by Toronto Hydro
in its sole discretion) by a percentage derived by dividing the actual demand materialized
in that 365-day period, by the commercial and industrial Estimated Incremental
Demand contemplated in this Offer to Connect.

For information about reduction in the amount of the Expansion Deposit after each 365 day
period, please contact Carrie George at (416) 542-3100 ext. 32076.

8. If after five (5) years from the energization date of the Expansion Assets, the total number of
forecasted connections or the commercial and industrial Estimated Incremental Demand
contemplated by this Offer to Connect has not materialized, Toronto Hydro shall retain any cash
held as an Expansion Deposit, or be entitled to realize on any letter of credit or bond held as an
Expansion Deposit and retain any cash resulting therefrom, with no obligation to return any
portion of such monies to the Customer at any time.

9. Toronto Hydro may at any time apply any cash held as an Expansion Deposit, or be entitled to
realize on any letter of credit or bond held as an Expansion Deposit and apply any cash
resulting therefrom, to offset any amount that the Customer is obligated to pay Toronto Hydro
pursuant to this Offer to Connect.
10. If the Customer pursues an Alternative Bid in accordance with SCHEDULE F, Toronto Hydro and the Customer agree to:

(a) Initially set the **Capital Contribution** to an amount equal to what the **Capital Contribution** would be if the Customer does not pursue an Alternative Bid;

(b) Initially set the **Expansion Deposit** to an amount equal to the TOTAL Ineligible for Alternative Bid Expansion Costs from SCHEDULE C;

(c) Adjust the **Capital Contribution** based on the results of a Final Economic Evaluation that Toronto Hydro shall conduct in accordance with SCHEDULE F after the **Expansion Work** is completed;

(d) Adjust the **Expansion Deposit** such that it amounts to the difference between the TOTAL Ineligible and Eligible Expansion Costs and the adjusted Capital Contribution.

Any adjustments to the **Capital Contribution** or the **Expansion Deposit** are to occur immediately after Toronto Hydro conducts the Final Economic Evaluation.

11. The **Capital Contribution** and the **Expansion Deposit** that the Customer shall provide to Toronto Hydro are contained in the table below. Should any amount contained in the table increase as a result of any adjustment provided for in this SCHEDULE D, the Customer shall provide the increase in the amount to Toronto Hydro upon receiving notice from Toronto Hydro of the adjustment. Should any amount contained in the table decrease as a result of any adjustment provided for in this SCHEDULE D, Toronto Hydro shall refund or release the decrease in the amounts to the Customer.

<table>
<thead>
<tr>
<th>Description</th>
<th>If Alternative Bid Not Pursued</th>
<th>If Alternative Bid Pursued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Contribution</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>HST (13%)</td>
<td>$ -</td>
<td>(To be adjusted after Expansion Work is Completed. Not payable until after it is adjusted.)</td>
</tr>
<tr>
<td>Capital Contribution and HST</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td><strong>Expansion Deposit Calculation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expansion Costs and HST (From SCHEDULE C)</td>
<td>$ -</td>
<td>(TOTAL Ineligible and Eligible Expansion Costs)</td>
</tr>
<tr>
<td>(*If Alternative Bid Pursued, see s. 10 above.)</td>
<td></td>
<td>$ -</td>
</tr>
<tr>
<td>Less Capital Contribution and HST</td>
<td>$ -</td>
<td>(TOTAL Ineligible Expansion Costs. To be adjusted after Expansion Work is Completed.)</td>
</tr>
<tr>
<td>(*If Alternative Bid Pursued, only amount that is payable immediately is captured here.)</td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>Expansion Deposit</td>
<td>$ -</td>
<td>(To be adjusted after Expansion Work is Completed.)</td>
</tr>
</tbody>
</table>
SCHEDULE E
FUTURE REBATES and RECENT EXPANSIONS

1. Toronto Hydro shall rebate a portion of the Capital Contribution to the Customer if:
   (a) a Future Customer connects to the Toronto Hydro distribution system;
   (b) the Future Customer is a Class 3, 4, or 5 customer as defined in Toronto Hydro’s Conditions of Service;
   (c) the Future Customer derives a benefit from the Expansion Assets that have been constructed as part of this Project; and
   (d) the Future Customer’s connection and load was not included in the economic evaluation that was conducted to calculate the Capital Contribution.

2. The portion of the Capital Contribution that Toronto Hydro shall rebate to the Customer will be determined by Toronto Hydro, in its sole discretion, by apportioning the overall benefits associated with the Expansion Assets to the customers benefiting from the Expansion Assets. If applicable, Toronto Hydro may consider any or all of the following factors when making its determination:
   (a) the relative name-plate rated capacity of the customers’ connections;
   (b) the relative load level of the customers;
   (c) the line length that Customer requires in comparison to the line length that the Future Customer requires in the context of the Expansion Assets;
   (d) the proportion of the five (5) year period of time after the energization date of the Expansion Assets that the Future Customer will be connected to the Toronto Hydro distribution system.

3. The Customer shall not be entitled to any interest for any rebated portion of the Capital Contribution.

4. The Customer shall make a Payment for Recent Expansion Benefits to Toronto Hydro if the Customer is connecting to the Toronto Hydro distribution system and:
   (a) the Customer will derive a benefit from assets that were constructed as part of a Recent Expansion Asset to connect the Other Customer;
   (b) the Customer’s connection was not anticipated and was not considered as part of the economic evaluation that was conducted for the Other Customer’s project; and
   (c) the Customer will begin deriving a benefit within five (5) years of the energization date of the Recent Expansion Assets.

[If no payment is required to rebate another customer]
5. For this Project, Toronto Hydro has determined that no Payment for a Recent Expansion Benefit is required.

OR [If payment is required to rebate another customer]
5. If Toronto Hydro receives Payment for Recent Expansion Benefits from the Customer, Toronto Hydro shall provide the Payment for Recent Expansion Benefits to the Other Customer as a rebate to the Other Customer’s contribution towards the construction of the Recent Expansion Assets.

6. Any Payment for Recent Expansion Benefits will not include interest.

7. For this Project, Toronto Hydro has:
   (a) identified Recent Expansion Assets that the Customer will benefit from; and
(b) determined the amount of the Payment for Recent Expansion Benefits by apportioning the overall benefits associated with the Recent Expansion Assets to the customers that have and will benefit from the Recent Expansion Assets.

A description of the Recent Expansion Assets and the amount of the Payment for Recent Expansion Benefits is contained below.

<table>
<thead>
<tr>
<th>Recent Expansion Assets and Payment for Recent Expansion Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Recent Expansion Assets:</td>
</tr>
<tr>
<td>• [insert description/location of Recent Expansion Assets]</td>
</tr>
<tr>
<td>(Recent Expansion OTC#: [insert OTC# or other identifier])</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Payment for Recent Expansion Benefits</th>
<th>$ -</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST (13%)</td>
<td>$ -</td>
</tr>
<tr>
<td>Payment for Recent Expansion Benefits and HST</td>
<td>$ -</td>
</tr>
</tbody>
</table>
SCHEDULE F
ALTERNATIVE BID PROCESS

1. In this schedule, **Facilities** means a portion of the **Connection Assets** and all of the **Expansion Assets** constructed using the **Alternative Bid**. The portion of the **Connection Assets** refers to the specific **Connection Assets** that are to be transferred to Toronto Hydro by the Customer, as identified by Toronto Hydro, in accordance with Toronto Hydro’s Conditions of Service.

2. The Customer may pursue **Eligible Alternative Bid Work** provided that the Customer agrees to transfer the **Facilities** to Toronto Hydro.

3. For the **Eligible Alternative Bid Work**, the Customer must use a **Qualified Contractor**. The Customer shall not be entitled to start performance of the **Eligible Alternative Bid Work** until the **Qualified Contractor** has been approved by Toronto Hydro for no less than 30 business days.

4. Toronto Hydro does not make any representation or warranty regarding any contractor selected by the Customer to do any work regardless of whether the contractor has been approved or qualified by Toronto Hydro or not. Toronto Hydro shall not be liable to the Customer in any way in respect of any work that is undertaken by the Customer using an **Alternative Bid**.

5. If the Customer decides to hire a **Qualified Contractor** to perform the **Eligible Alternative Bid Work**, the Customer will be required to select, hire, and pay the **Qualified Contractor**’s costs for such work and to assume full responsibility for all of the **Eligible Alternative Bid Work**. The Customer shall complete all of the **Eligible Alternative Bid Work** prior to energization by Toronto Hydro.

6. The Customer shall ensure that the **Eligible Alternative Bid Work** and any related work is done in accordance with Toronto Hydro’s standards, specifications, system plans, and designs. This applies to and includes the following:

   (i) the design of the **Facilities**;
   (ii) the engineering of the **Facilities**; and
   (iii) the layout of the **Facilities**.

7. The Customer and its **Qualified Contractor** shall only use materials that meet the same specifications as Toronto Hydro approved materials (i.e. same manufacturers and same part numbers). Once the Customer has hired a **Qualified Contractor**, the Customer may request from Toronto Hydro, and if requested, Toronto Hydro shall provide, the listing of approved materials that may be required for the **Eligible Alternative Bid Work**.

8. The Customer will be required to pay for administering the contract with the **Qualified Contractor**, or if agreed by Toronto Hydro, pay Toronto Hydro a fee for performing this activity on the Customer’s behalf. Upon request, if Toronto Hydro is agreeable to performing such activity, Toronto Hydro will advise the Customer of the amount of the fee. Administering the contract includes, among other things, acquiring all permissions, permits, and easements.

9. The Customer shall obtain Toronto Hydro’s review and approval for the **Eligible Alternative Bid Work** prior to Toronto Hydro connecting the **Facilities** to the Toronto Hydro distribution system. The review and approval is required to, among other objectives, ensure conformance with specifications and distribution system planning requirements for the design, engineering, and layout of the **Facilities**. If all of Toronto Hydro’s requirements related to the **Eligible Alternative Bid Work**, including the requirements set out in this schedule, have not been completed satisfactorily to Toronto Hydro, acting reasonably, the Project will not be energized, until the **Eligible Alternative Bid Work** is in compliance with all of Toronto Hydro’s requirements.
10. After the Customer has performed Eligible for Alternative Bid, Connection Work, and Toronto Hydro has inspected, approved, and energized the constructed Eligible for Alternative Bid, Connection Work, the Customer shall transfer the Eligible for Alternative Bid, Connection Assets, to Toronto Hydro and Toronto Hydro shall, assume ownership of the Eligible for Alternative Bid, Connection Assets, as of the date that those assets were energized.

11. After the Customer has performed Eligible for Alternative Bid, Expansion Work, and Toronto Hydro has inspected, approved, and energized the constructed Eligible for Alternative Bid, Expansion Work, the Customer shall transfer the Eligible for Alternative Bid, Expansion Assets, to Toronto Hydro and Toronto Hydro shall assume ownership of the transferred assets as of the date that those assets were energized. Once Toronto Hydro has assumed ownership of all Eligible for Alternative Bid, Expansion Assets, Toronto Hydro shall, pay to the Customer, a Transfer Price.

12. The Transfer Price will be the lower of the Customer’s Costs or the TOTAL Eligible for Alternative Bid Expansion Costs set out in SCHEDULE C. The Customer’s Costs means:

(a) the amount the Customer paid to have the Eligible for Alternative Bid Expansion Work defined in SCHEDULE B completed, as provided by evidence satisfactory to Toronto Hydro; and

(b) the Additional Costs for Alternative Bid Work charged by Toronto Hydro.

For greater clarity, the Customer’s Costs are not to include any costs associated with the completion of Total Eligible for Alternative Bid Connection Work.

13. Toronto Hydro, at its sole discretion, may refuse to include a particular Customer’s Cost in the Transfer Price if Toronto Hydro is of the opinion that the particular Customer’s Cost was not properly incurred by the Customer.

14. The Customer must provide Toronto Hydro with all evidence of the Customer’s Costs and the calculation setting out the Customer’s Costs within 30 days of the Expansion Assets that make up the Facilities being energized. If the Customer fails to provide either the evidence or the calculation for Customer’s Costs, then the amount of the Transfer Price will be the amount set out in SCHEDULE C of this Offer to Connect for Total Eligible Alternative Bid Expansion Costs.

15. Toronto Hydro may deduct any amount payable by the Customer to Toronto Hydro from the Transfer Price owing to the Customer by Toronto Hydro. This includes any Expansion Deposit that the Customer is to or will have to provide Toronto Hydro.

16. Toronto Hydro shall carry out a Final Economic Evaluation after the Eligible for Alternative Bid, Expansion Assets are energized. The Final Economic Evaluation will be based on the amounts used in this Offer to Connect for costs and forecasted revenues, and will include the final amount of the Transfer Price to be paid by Toronto Hydro to the Customer. The Final Economic Evaluation will be used to determine adjustments to the Capital Contribution and Expansion Deposit contained in SCHEDULE D. Toronto Hydro and the Customer shall arrange to settle any amounts owing as necessary, including by way of set off. Toronto Hydro shall provide a copy of the Final Economic Evaluation to the Customer.

17. Notwithstanding the provisions in SCHEDULE D, where the Customer has pursued an Alternative Bid, Toronto Hydro will retain 10% of the Expansion Deposit determined by the Final Economic Evaluation for a warranty period of up to two (2) years. The warranty begins at the end of the Realization Period.

18. Toronto Hydro shall return to the Customer the unused portion of the 10% of the Expansion Deposit, if any remains, at the end of the two-year warranty period.
19. Toronto Hydro is entitled to retain and use, at any time, any **Expansion Deposit** in its possession to address or remedy any deficiencies in the facilities that are identified by Toronto Hydro. Should Toronto Hydro’s cost to address or remedy a deficiency exceed the amount of any **Expansion Deposit**, the Customer shall indemnify Toronto Hydro for all costs associated with addressing or remedying the deficiency. Examples of deficiencies that Toronto Hydro may address or remedy include but are not limited to:

(a) incomplete construction;
(b) construction that is not to the proper design or technical standards and specifications;
(c) assets that are constructed using materials that are not approved by Toronto Hydro;
(d) assets that do not operate properly when energized.
SCHEDULE G
GENERAL TERMS & CONDITIONS

1. ASSIGNMENT
1.1 Neither party may assign this Offer to Connect without the prior written consent of the other party, such consent not to be unreasonably withheld.

2. EASEMENTS
1.1 Upon request by Toronto Hydro, the Customer shall, at its own expense, execute, register and provide a solicitor’s opinion on title in a form acceptable to Toronto Hydro, within the time period specified by Toronto Hydro, and subject only to those encumbrances permitted in writing by Toronto Hydro, such easement agreements as Toronto Hydro may require for the installation and continued existence of any electrical or telecommunication plants or access to same for the life of such plant or as otherwise required to perform its responsibility as a distribution company.

2.2 The customer acknowledges that in order for an easement to be registered, it shall be required, at its expense, to arrange for and register any necessary documentation required by the appropriate Land Registry Office, including a Reference Plan, prepared by an Ontario Land Surveyor, describing the extent of the lands required for the easement.

3. FORCE MAJEURE
3.1 Force Majeure means any act, event, cause or condition that is beyond Toronto Hydro’s reasonable control, including wind, ice, lightning or other storms, earthquakes, landslides, floods, washouts, fires, explosions, contamination, breakage of equipment or machinery, delays in transportation, strikes, lockouts or other labour disturbances, civil disobedience or disturbances, war, acts of sabotage, blockades, insurrections, vandals, riots, epidemics, or loss of any relevant license.

3.2 If by reason of Force Majeure, Toronto Hydro is unable, wholly or partially, to perform or comply with any or all of its obligations under this Offer to Connect, it shall be relieved of such obligations, and any liability, including liability for any injury, damage or loss to the Customer caused by such event of Force Majeure, for failing to perform or comply with such obligations, during the continuance of Force Majeure.

4. LIMITATION OF LIABILITY
4.1 Toronto Hydro shall not be responsible for the acts or omissions of the Customer or its employees, officers, directors, contractors, subcontractors or agents.

4.2 Neither Toronto Hydro nor any of its employees, agents, officers, directors or other representatives (“Representatives”) shall be liable for any loss, injury or damage to persons or property caused in whole or in part by negligence or fault of the Customer, or any of the Customer’s Representatives, contractors or subcontractors.

4.3 Notwithstanding any other provision in this Offer to Connect, or any applicable statutory provision, Toronto Hydro and its Representatives shall only be liable for any damages which arise directly out of the wilful misconduct or negligence of Toronto Hydro or its Representatives.

4.4 Neither Toronto Hydro nor any of its Representatives shall be liable under any circumstances whatsoever for any loss of profits or revenues, business interruption losses, loss of contract or loss of goodwill, or for any indirect, consequential, incidental or special damages, including but not limited to punitive or exemplary damages, arising from any breach of this Offer to Connect, fundamental or otherwise, or from any tortious acts, including the negligence or willful misconduct of it or its Representatives, however arising.

4.5 No action arising out of this Offer to Connect, regardless of the form thereof, may be brought by either party more than two (2) years following the date the cause of action arose, provided however that, subject to any applicable law, Toronto Hydro may bring an action for non-payment of amounts, or non-delivery of deposits, required to be paid or delivered by the Customer under this Offer to Connect at any time.

4.6 The Customer shall indemnify and save harmless Toronto Hydro and its Representatives from any action, claim, penalty, damages, losses, judgments, settlements, costs and expenses or other remedy brought by any party or governmental authority, arising out of or resulting from any negligent act or failure to act or any willful misconduct by the Customer or any of its Representatives.

4.7 All of the provisions of Sections 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 shall survive the termination of this Offer to Connect.

5. NOTICE
5.1 Any notice to be given under this Offer to Connect shall be in writing and delivered by prepaid registered mail, hand, courier or facsimile to the contact for the parties as set forth in the Offer to Connect.

5.2 Delivery by facsimile shall be deemed received on the day following transmittal provided the facsimile is received as confirmed by the issuance of a confirmation receipt at the point of transmission.

5.3 Delivery by hand or courier shall be deemed received on the date delivered.
5.4 Delivery by prepaid registered mail shall be deemed received on the 5th business day after mailing.

5.5 Either party may change its address for notice by providing written notice of that change to the other party.

6. REVISED PLANS
6.1 If the Customer submits revised plans or requires additional design work, Toronto Hydro may provide, at a cost, a new offer based on the revised plans or the additional design work.

7. SECURITY INTEREST
7.1 As security for its obligations under this Offer to Connect, the Customer grants to Toronto Hydro a present and continuing security interest in, and lien on (and right of set-off against), and assignment of all money, cash collateral and cash equivalent collateral and any and all proceeds resulting therefrom or the liquidation thereof, delivered as a deposit or otherwise pursuant to the terms of this Offer to Connect, or for the benefit of Toronto Hydro.

7.2 The Customer agrees to take such action as Toronto Hydro reasonably requires in order to perfect Toronto Hydro's first-priority security interest in, and lien on (and right of set-off against), such collateral and any and all proceeds resulting therefrom or from the liquidation thereof.

7.3 Toronto Hydro shall apply the proceeds of the collateral realized upon the exercise of any such rights or remedies to reduce Customer's obligations under this Offer to Connect (Customer remaining liable for any amounts owing to Toronto Hydro after such application), subject to Toronto Hydro's obligation to return any surplus proceeds remaining after such obligations are satisfied in full.

8. TAXES
8.1 Unless specified, none of the amounts payable or deliverable under the Offer to Connect include harmonized sales taxes or any other taxes that may be payable.

8.2 The Customer shall pay all such taxes in accordance with applicable laws.

9. TERMINATION
9.1 Each of the following shall constitute an event of default ("Event of Default"): (i) the Customer fails to make any payment at the time specified for payment in this Offer to Connect and such failure has not been remedied within three (3) days notice of such failure; (ii) the Customer fails to deliver any deposit, including additional deposits within the time period specified for delivery in this Offer to Connect; (iii) the Customer fails to execute and deliver any agreement, or deliver any other document, within the time period specified for execution and/or delivery; (iv) the Customer fails to commence the Connection Work or the Expansion Work within 1 year from the date of this Offer to Connect; (v) the Customer cancels the Project for any reason; (vi) the Customer fails to comply with any other covenant or obligation in this Offer to Connect and such failure has not been remedied (where it is possible to remedy such failure) within 15 days of the initial failure to perform; (vii) a resolution has passed, or documents filed at an office of public record, for the merger, amalgamation, dissolution, termination of existence, liquidation or winding-up of the Customer, unless the prior consent of Toronto Hydro has been obtained; (viii) a receiver, manager, receiver-manager, liquidator, monitor or trustee in bankruptcy of the Customer or any of its property is appointed by any government authority, and such receiver, manager, receiver-manager, liquidator, monitor or trustee is not discharged within 30 days of appointment; or, if by decree of any government authority, the Customer is adjudicated bankrupt or insolvent, or any substantial part of its property is taken, and such decree is not discharged within 30 days after the entry thereof; or, if a petition to declare bankruptcy or to reorganize such party pursuant to any applicable law is filed against the Customer and is not dismissed within 30 days of such filing; (ix) the Customer files, or consents to the filing of, a petition in bankruptcy or seeks, or consents to, an order or other protection under any provision of any legislation relating to insolvency or bankruptcy ("Insolvency Legislation"); or files, or consents to the filing of, a petition, application, answer or consent seeking relief or assistance in respect of itself under provision of any Insolvency Legislation; or files, consents to the filing of, an answer admitting the material allegations of a petition filed against it in any proceeding described herein; or makes an assignment for the benefit of its creditors; or admits in writing its inability to pay its debts generally as they become due; or consents to the appointment of a receiver, trustee, or liquidator over any, or all, of its property.

9.2 Upon the occurrence of an Event of Default, Toronto Hydro may, at its sole discretion, do any one or more of the following:
11. WARRANTIES

11.1 Except as expressly set forth in this Offer to Connect, Toronto Hydro provides no warranties, for fitness, for purpose, or otherwise, whether statutory or otherwise, to the Customer.

12. MISCELLANEOUS

12.1 This Offer to Connect, including all attached Schedules, shall constitute the entire agreement between the parties, and there are no other agreements or understandings, either written or oral, to conflict with, alter or enlarge this Offer to Connect unless agreed to in writing between the parties subsequent to the effective date of this Offer to Connect.

12.2 Failure or delay by Toronto Hydro in enforcing any right under, or provision of this Offer to Connect shall not be deemed a waiver of such provision or right with respect to the instant, or any previous, or subsequent, breach.

12.3 This Offer to Connect shall be governed by the laws of the Province of Ontario and the laws of Canada as applicable.

12.4 The parties irrevocably attorn to the jurisdiction of the courts of Ontario with respect to any matter arising under or related to this Agreement.

12.5 Toronto Hydro shall be entitled to access at all reasonable times to any of the Customer’s properties to perform the services in this Offer to Connect.

12.6 Interest on unpaid amounts shall bear interest at the rate of 1.5 percent calculated and compounded monthly (19.56 percent per annum) at and from the due date up to and including the date of payment in full of such amount, together with all interest accrued to the date of payment.

12.7 Toronto Hydro and the Customer agree to execute and deliver such further documents as may be required for either party to fulfill its obligations and enforce its rights under this Offer to Connect.

12.8 If any provision of this Offer to Connect is declared illegal, invalid or unenforceable for any reason whatsoever, to the extent permitted by law, such illegality, invalidity or unenforceability shall not affect the legality, validity or enforceability of any of the other provisions.

12.9 This Offer to Connect and the obligations of the parties under it are subject to all applicable present and future laws, rules, regulations and orders of any regulatory or legislative body or other duly constituted authority having jurisdiction over Toronto Hydro or the Customer.

12.10 Time shall be of the essence.

12.11 If there is a conflict between this Offer to Connect and Toronto Hydro’s Conditions of Service, this Offer to Connect shall govern.

12.12 Any schedules, timelines or related Gantt charts (each a “Project Schedule”) provided to the Customer in connection with this Offer to Connect is for discussion purposes only and the dates on such Project Schedules are subject to change. The Customer acknowledges that the Project Schedules do not create a legally binding obligation on Toronto Hydro and Toronto Hydro shall have no liability whatsoever for any damages if the dates on such Project Schedules are not met.
1. In accordance with the requirements of the Ontario Energy Board’s Distribution System Code, Toronto Hydro has performed an economic evaluation to determine the amount of the Capital Contribution that the Customer shall pay to Toronto Hydro. The economic evaluation, which arrived at the Capital Contribution contained in SCHEDULE D, and is referred to as the Initial Economic Evaluation, is appended to this schedule.

2. The Initial Economic Evaluation is based on a present value (i.e. discounted cash flow) methodology that determines the net present value (“NPV”) of the Project over a period of twenty-five (25) years. The Initial Economic Evaluation includes cash flows for Incremental Revenues, Expansion Costs, other capital costs if applicable, OM&A Costs, and taxes. Any economic evaluations that may be required in the future will be based on the same methodology.

3. If the NPV of the Project is greater than zero, then the Project is financially viable and a Capital Contribution is not required. If the NPV of the Project is less than zero, the Project is not financially viable and a Capital Contribution is required to bring the NPV to zero (i.e. neutral).

[Append “Summary” tab from the economic evaluation]
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 79:

Reference(s): Exhibit 2B, Section E5, pp. 6-7

Alectra was able to negotiate approximately a fifty-three percent (53%) capital contribution from road authorities for proposed relocation work in 2020 (EB-2018-0016, Tr. Vol 1). Why cannot THESL negotiate similar arrangements?

RESPONSE:

Toronto Hydro is unable to comment on Alectra's cost sharing agreements and the underlying negotiations between the utility and its road authorities. What Toronto Hydro is able to provide in response to this question is an affirmation that when negotiating with road authorities the utility always strives to secure the best cost sharing arrangements for its customers. The Public Services Works on Highways Act (PSWHA)\(^1\) outlines the default cost sharing responsibilities for relocation work initiated by road authorities. In the case of like-for-like relocation projects, it is very difficult for the utility to secure a cost sharing arrangement that is better than what the PSWHA provides because the road authorities understand and invoke the PSWHA framework. Where the road authority asks for a non like-for-like relocation, Toronto Hydro successfully takes the position that the incremental costs should be borne by the road authority.

\(^1\) Public Service Works on Highways Act, R.S.O. 1990, c. P.49
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 80:

Reference(s): Exhibit 2B, Section E5, p. 6

As the railway crossing costs included in the system access cost forecasts for 2020-2024, please account for this drastic increase.

RESPONSE:

The increase in railway crossing costs is driven entirely by the provincial government’s transit investment plans. Please refer to Exhibit 2B, Section E.5.2.4.1 for more details.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 81:
Reference(s): Exhibit 2B, Section E5, p. 8

Does not the use of the deferral account for system access costs reduce the incentive of THESL to negotiate the best possible deal with the various agencies, including its parent company, and the provincial government? Please discuss an approach that would be a win-win for both shareholders and ratepayers.

RESPONSE:
No. The funding mechanism for externally initiated relocation work has no influence on Toronto Hydro’s negotiation strategy with agencies and other third parties who request relocations. Toronto Hydro respectfully rejects the proposition that the deferral account reduces the incentive of the utility to negotiate the best possible deal. As noted in Toronto Hydro’s response to interrogatory 2B-BOMA-79, Toronto Hydro always strives to secure the best possible cost sharing arrangement for its customers, irrespective of how the costs of the investment are to be recovered from ratepayers.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 82:

Reference(s): Exhibit 2B, Section E5, p. 9

a) Please provide the "business case" for each of THESL's Metrolinx West LRT, Metrolinx Regional Express Rail, TTC's Scarborough Subway Extension, TTC East Access Program, John St. Revitalization, Wellington Street scope, York-Bay-Yonge Densification, and Harbour Street Widening, comparable to the explanation for THESL's proposed expenditure to relocate assets for the cross-town Eglinton LRT. In addition, please provide comparable information, if available, on each of the Upcoming Projects, on p16.

b) What are the proposed allocations of costs?

c) What are the expansion proposals for THESL's infrastructure which will be done at the same time as the above asset relocations?

d) What additional expansion costs does THESL plan for 2020 and 2021, and are these costs included in Table 4 at p7?

RESPONSE:

a) Information comparable to that provided for the Eglinton Crosstown LRT can be found for each major project on pages 10 through 16 of Exhibit 2B, Section 5.2. Comparable information for the upcoming projects on page 16 is not available.

Panel: Distribution System Capital and Maintenance
Panel: Distribution System Capital and Maintenance

b) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-55.

c) An overview of Toronto Hydro’s expansion proposals for each major project can also be found in the information provided on pages 10 through 16 of Exhibit 2B, Section 5.2.

d) Toronto Hydro has not included additional forecast expansion costs beyond those associated with the major projects referenced in parts (a) through (c) above.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 83:
Reference(s): Exhibit 2B, Section E5.4

Please provide a Table which shows actual and forecast expenditures from 2015 to 2024 for each of the five (5) programs that make up the System Access capex. Please include totals for each line for the 2015-2019, and 2020-2024 periods.

RESPONSE:
Please refer to Appendix 2-AA, which is filed at Exhibit 2A, Tab 4, Schedule 2.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 84:
Reference(s): Exhibit 2B, Section E6 (General)

Please provide a Table, as requested above, for each of the seven (7) programs included in the System Renewal Tranche of the 2020-2024 capital budget. For the Area Conversion Program, please show separate lines for Rear Lot Conversion and Box Construction Conversion.

RESPONSE:

Please see Table 1 below.

Table 1: 2020-2024 Capital Budget for System Renewal Programs ($ Millions)

<table>
<thead>
<tr>
<th>Projects</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2020-2024</th>
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<tbody>
<tr>
<td></td>
<td>Forecast</td>
<td>Forecast</td>
<td>Forecast</td>
<td>Forecast</td>
<td>Forecast</td>
<td>Total</td>
</tr>
<tr>
<td>Box Construction</td>
<td>22.7</td>
<td>20.8</td>
<td>21.1</td>
<td>22.0</td>
<td>20.7</td>
<td>107.3</td>
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<tr>
<td>Rear Lot Conversion</td>
<td>18.8</td>
<td>26.3</td>
<td>25.2</td>
<td>28.3</td>
<td>14.9</td>
<td>113.5</td>
</tr>
<tr>
<td>Network System Renewal</td>
<td>18.6</td>
<td>19.3</td>
<td>18.5</td>
<td>17.7</td>
<td>18.3</td>
<td>92.4</td>
</tr>
<tr>
<td>Reactive and Corrective Control</td>
<td>61.2</td>
<td>62.4</td>
<td>63.5</td>
<td>64.4</td>
<td>65.8</td>
<td>317.2</td>
</tr>
<tr>
<td>Stations Renewal</td>
<td>27.5</td>
<td>35.3</td>
<td>29.4</td>
<td>27.0</td>
<td>22.4</td>
<td>141.5</td>
</tr>
<tr>
<td>Underground Renewal – Downtown</td>
<td>15.1</td>
<td>22.5</td>
<td>23.9</td>
<td>30.0</td>
<td>30.6</td>
<td>122.0</td>
</tr>
<tr>
<td>Underground Renewal – Horseshoe</td>
<td>93.0</td>
<td>88.7</td>
<td>90.3</td>
<td>93.1</td>
<td>95.2</td>
<td>460.3</td>
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<tr>
<td>Overhead System Renewal</td>
<td>49.8</td>
<td>50.4</td>
<td>51.3</td>
<td>56.5</td>
<td>57.7</td>
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<td>System Renewal Total</td>
<td>306.6</td>
<td>325.7</td>
<td>323.1</td>
<td>339.0</td>
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<td>1,619.9</td>
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</table>
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 85:

Reference(s): Exhibit 2B, Section E6.1

Please provide a prioritized list of rear lot conversion projects that are included in the Rear Lot Conversion Program.

RESPONSE:

Exhibit 2B, Section E6.1.4.1, Table 10 provides a list of rear lot areas that the utility has identified as priority conversion areas for the 2020-2024 period.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 86:
Reference(s): Exhibit 2B, Section E6.1

Please provide the number of customers served by rear lot equipment in Toronto. How many of these arrangements have been connected to date by year? What percentage have been converted to front lot underground, each year (a) beginning in 2015; (b) in years before 2015 when such work was done?

RESPONSE:
Please refer to Exhibit 2B, Section E2, Figure 16 on page 26, which provides the historical and projected number of customers served by rear lot plant for each of the years 2015 to 2029. In all rear lot conversion capital projects, rear lot distribution has been converted to front lot underground distribution.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 87:
Reference(s): Exhibit 2B, Section E6.1 (Priorities)

Please provide a prioritization table for the 2020-2024 system renewal projects, and for each of 2020, 2021, 2022, 2023, and 2024, separately, of the system renewal programs listed at p1 (E6). In doing so, please consider a rear lot conversion and box replacement as two "separate programs".

RESPONSE:

Exhibit 2B, Section E6.1, Table 10 provides a list of rear lot areas that the utility has identified as priority conversion areas for the 2020-2024 period.

Exhibit 2B, Section E6.1, Table 12 provides a list of box construction areas prioritized by station for the 2020-2024 period and beyond.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 88:

Reference(s): Exhibit 2B, Section E6.1, p. 3

a) Does THESL have an ongoing program to replace transformers of all types containing PCBs? If so, please describe the budgets and the plans to remove all PCB-transformers by 2024. Please provide budgets/actuals for the work from 2015-2019, and 2020-2024.

b) How many of THESL's retained transformers are currently leaking oil? Please differentiate by category, eg. pole top, pad-mounted, vault, are:
   i) currently leaking material amounts of oil;
   ii) currently leaking some oil;
   iii) are leaking oil that contain PCBs;
   iv) contain PCBs but are not leaking oil;
   v) what is THESL's plan to eliminate all transformers which contain PCBs prior to 2024?

RESPONSE:

a) Toronto Hydro does not have an ongoing program to replace transformers of all types containing PCBs. As described in Exhibit 2B, Section E2, page 36, Toronto Hydro is managing PCB risks through inspection and testing under its maintenance programs (discussed in Exhibit 4A, Tab 2, Schedules 1-4) and through targeted asset replacement in capital programs such as Overhead System Renewal (Exhibit 2B,
Section E6.5), Underground System Renewal (Sections E6.2 and E6.3), Stations Renewal (Exhibit 2B, Section 6.6), and Reactive and Corrective Capital (Section E6.7).

Despite not having an ongoing program, Toronto Hydro is continuously monitoring PCB risks and may develop dedicated projects under the above mentioned programs to replace transformers with PCBs where risks are unacceptable. For example, in 2015 and 2016, Toronto Hydro observed an increase in the number of oil spills containing PCBs (as shown in Exhibit 2B, Section C2, Figure 12, p. 24) and following analysis, determined that submersible transformers contributed disproportionately to the increase. Dedicated projects were executed in 2017 and 2018 to replace 748 submersible transformers to mitigate PCB risks. In aggregate, these projects cost $13.7 million.

Over the 2020-2024 period, Toronto Hydro estimates that approximately $150 million of the total System Renewal expenditure will contribute to the replacement of transformers with PCBs, with the vast majority of this equipment forecasted to be operating beyond useful life at the time of replacement.

b) Statistics as of January 8th, 2018:
   i) Transformers currently leaking material amounts of oil: 0
   ii) Transformers currently leaking some oil: 40 (i.e. 28 underground, 10 network, and 2 station transformers)
   iii) Transformers currently leaking oil that contains PCB: 0
   iv) Transformers that contain PCBs but are not leaking oil: Please refer to the “Oil Containing PCBs” column of Exhibit 2B, Section D2, Table 1, p. 12.

---

1 Toronto Hydro removes transformers that are known to be leaking material amounts of oil on an urgent basis.
2 Toronto Hydro removes transformers that are known to be leaking PCBs on an urgent basis.
Please refer to Exhibit 2B, Section E2 at page 36 along with the response to part (a) above.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 89:

Reference(s): Exhibit 2B, Section E6.1, p. 4

a) Please describe THESL’s tree trimming program, inspection and removal, and its budgets/actuals for 2015-2019, and 2020-2024.

b) Has THESL investigated the new program HONI Transmission has recently adopted to modify its tree trimming cycle and approach?

RESPONSE:

a) Please refer to Exhibit 4A, Tab 2, Schedule 1, section 7 for details of Toronto Hydro’s Vegetation Management activities and expenditures.

b) Toronto Hydro has not investigated any recent changes to Hydro One’s vegetation management practices for transmission.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 90:

Reference(s): Exhibit 2B, Section E6.1, p. 6

The outage differential for rear lot/front lot repair appears from Figure 2 to range from less than one (1) hour to one and one-half (1.5) hours, not the one (1) to three (3) hours stated under the graph. Why the discrepancy?

RESPONSE:

There is no reference to “one (1) to three (3) hours” in this section. The text under Figure 2 states “outages on rear lot feeders were 1.3 hours longer than outages on the system as a whole.” Please refer to Exhibit 2B, Section E6.1.3.1, Figure 2.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 91:
Reference(s): Exhibit 2B, Section E6.1, p. 7

Please provide a prioritized list (with budget) of the eight (8) rear lot areas, e.g. Jamestown, Hartsdale, etc., that THESL plans to convert over the 2020-2024 period.

Please explain how the various areas conversions were prioritized.

RESPONSE:
Table 1 below includes the 2020 – 2024 forecasts for the eight project areas identified in Exhibit 2B, Section E6.1, Table 10. The prioritized list was developed based on reliability (i.e. outage duration and frequency) and projects that started in the previous rate filing period.

Table 1: 2020-2024 Forecast Expenditures for Rear Lot Projects ($M)

<table>
<thead>
<tr>
<th>Year</th>
<th>Projects</th>
<th>Forecast Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Thorncrest Civil</td>
<td>18.8</td>
</tr>
<tr>
<td>2021</td>
<td>Thorncrest Electrical</td>
<td>26.3</td>
</tr>
<tr>
<td></td>
<td>Jamestown Civil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Markland Woods Civil</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>Jamestown Electrical</td>
<td>25.2</td>
</tr>
<tr>
<td></td>
<td>Markland Woods Electrical</td>
<td></td>
</tr>
</tbody>
</table>
## Martin Grove Gardens Civil

<table>
<thead>
<tr>
<th>2023</th>
<th>Martin Grove Gardens Electrical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mount Olive Electrical</td>
</tr>
<tr>
<td></td>
<td>Kingsview Civil</td>
</tr>
<tr>
<td></td>
<td>Richview Park Civil</td>
</tr>
<tr>
<td></td>
<td>Willowridge Civil</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2024</th>
<th>Kingsview Electrical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Richview Park Electrical</td>
</tr>
<tr>
<td></td>
<td>Willowridge Electrical</td>
</tr>
<tr>
<td></td>
<td>Future Site (Civil)</td>
</tr>
</tbody>
</table>

(no electrical phase during this filing - equivalent to 135 customers for following filing)
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 92:

Reference(s): Exhibit 2B, Section E6.1, p. 10, Table 6

Please confirm that replacement of rear lot poles on an "area" basis will result in the fifty-five percent (55%) poles in good, or moderate deterioration (fair) condition being replaced along with poles in materially determined condition. What is the cost of doing this? If this is not the case, please explain, and provide the correct number.

RESPONSE:

Toronto Hydro has not considered alternatives to replacing rear lot on an area basis, as the purpose of the program is to convert all rear-lot plant to front-lot plant, and this cannot be done on a spot replacement basis.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 93:

Reference(s): Exhibit 2B, Section E6.1, p. 13

- a) What percentage of rear lot infrastructure does not currently comply with Electrical Safety Utilities Safety Order 129? What percentage of the rear lot equipment use 4.16 kV design?

- b) Given the increased cost of undergrounding rear lot conductors, transformers, and equipment, and the advances in tree trimming strategies, the difficulty of inspecting and retrofitting underground infrastructure, and ratepayers preference for lowest possible price increases, why does THESL propose to continue to increase overall system costs by moving from overhead (rear lot) to underground?

- c) Has THESL considered asking ratepayers to pay for rear lot conversion costs, in whole or in part?

RESPONSE:

- a) Toronto Hydro does not track the percentage of its rear lot infrastructure that is out of compliance with Electrical Utility Safety Rule 129. About 99% of Toronto Hydro’s rear lot equipment is 4.16 kV.
b) A detailed discussion of the justification (including an analysis of options considered) for the Rear Lot Conversion segment in the Area Conversion program are provided in Exhibit 2B, Sections E6.1.3.1 and E6.1.5.1.

c) No, Toronto Hydro has not considered asking specific customers to make direct customer contributions to cover the costs of rear lot conversion.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 94:
Reference(s): Exhibit 2B, Section E6.1, p. 18

What percentage have box construction poles and structures in poor or very poor condition? By how much will distribution losses been reduced by converting from 4.16 kV to 13.8 kV, or from 4.16 to 27 kV? What studies has THESL, or the industry, done to demonstrate the cost savings from using high voltage feeders? What is the timeframe for the removal of all 4.16 kV circuits, and the approximate cost? What voltage is required to connect a typical new condominium project?

RESPONSE:
A total of 13% of Toronto Hydro’s Box Construction wood pole population is HI4 (material deterioration), while 2% is HI5 (end of life). However, it should be noted that functional obsolescence, rather than condition, is the trigger driver for the Box Construction Conversion Segment. As a result of safety, reliability, access, equipment, capacity, and procurement issues, Toronto Hydro no longer builds this legacy 4.16 kV overhead design. Please refer to Exhibit 2B, Section E6.1.3 for a detailed discussion of the drivers of this segment.

Toronto Hydro has not conducted recent studies to quantify cost savings from using higher voltage primary feeders. The need for box construction conversion is more functional obsolescence than line loss reduction. Nevertheless, technical losses are generally lower at
higher voltages.\textsuperscript{[1]} In general, increasing voltage by a magnitude of two (i.e. 100\% increase) will result in a reduction of losses by a magnitude of four (i.e. 75\% decrease).

Toronto Hydro expects to have removed all 4.16 kv circuits in the downtown area by 2027. From 2020 – 2027, the total expected investment will be approximately $150 million.

Typical new condominium building are supplied by 13.8kV in the downtown and 27.6kV in the Horseshoe.

\textsuperscript{[1]} See, for example, T.A. Short, \textit{Electric Power Distribution Handbook}, 2004, Section 1.3 “Primary Voltage Levels”
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 95:
Reference(s): Exhibit 2B, Section E6.1

Please describe what the change from box construction to single pole method consists of.
What new assets are put in place and what old assets are being replaced?

RESPONSE:
Please refer to Exhibit 2B, Section E6.1.3.2 for a description of box construction
conversion. Figure 9 in the referenced section provides an image of a box construction
pole before and after conversion. Box construction projects involve conversion from 4 kV
to 13.8 kV or 27.6 kV standards. This necessitates the replacement of all major and minor
assets on the pole line.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 96:

Reference(s): Exhibit 2B, Section E6.1, p. 27

What is the increase in unit cost of rear lot forecast for the plan year, given that the total spending on the program is proposed to increase from $65.1M in 2015-2019 to $113.5M in 2020-2024, and $46M, or about sixty-five percent (65%)?

RESPONSE:

The spending in 2015-2019 is lower than the 2020-2024 forecast primarily because Toronto Hydro completed a high volume of electrical work (which is significantly less expensive than civil work), during the 2015-2019 period. The proposed 2020-2024 spending profile represents a more balanced mix of civil and electrical work.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 97:

Reference(s): Exhibit 2B, Section E6.1, p. 27

a) Please confirm that Table 12 sets out the priority assigned to the service projects. Please provide an explanation of how the order was established. If not the priority, please provide the priority list. Please also provide the priority of projects within each two (2) year period, e.g. Sherbourne MS vs. Queensway MS.

b) Why would whole trees need to be cut down to make room for an overhead lien? Could a passageway not be created by trimming?

RESPONSE:

a) Confirmed. Table 12 sets out the priority order for box construction projects. In establishing these priorities, Toronto Hydro considered the following factors:

- Reliability
- Asset age and condition
- External dependencies

Projects within each two year period have equal priority.

b) The reference to “cut down” is intended to mean “trimmed” or “cut down to size”; not “to cut down an entire tree.”
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 98:

Reference(s): Exhibit 2B, Section E6.2, p. 1

a) Please confirm that outages on the underground system take thirty-five percent (35%) longer to restore than outages on the overhead system, applies whether the overhead system is rear lot, or front lot. If not, please provide the correct number.

b) Please provide the current condition – poor, fair, good, very good, of (i) direct buried XLPE cable over the 2020-2024 period; (ii) the estimated 1,900 underground transformers to be replaced in 2020-2024; (iii) the 230 underground switches to be replaced in 2020-2024.

RESPONSE:

a) This statistic is based on average duration of outages due to failure of all underground equipment compared to failure of all overhead equipment regardless of the location (front or rear lot) of the equipment.

b) Toronto Hydro’s CNAIM model does not currently include the asset condition for cables and vault switches. Toronto Hydro is unable to provide the asset condition of the estimated 1900 underground transformers and 230 underground switches to be replaced as specific project scopes under the proposed investment plan are not available at this time. Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b) for an explanation as to why Toronto Hydro has not yet specified
2020-2024 projects. Please refer to Exhibit 2B, Section E6.2, Tables 7 and 8 for condition data for all underground transformers and padmounted switches, respectively.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 99:
Reference(s): Exhibit 2B, Section E6.2, p. 3

a) How many underground transformers contain PCB, and need to be replaced by 2024?

b) How have the "useful life" of assets listed in Table 4 been determined?

RESPONSE:

a) Please refer to Exhibit 2B, Section E6.2.3.2, page 20, line 2.

b) Please see Toronto Hydro's response to interrogatory 1B-CCC-12.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 100:

Reference(s): Exhibit 2B, Section E6.2, p. 1

Please confirm that the 280,000 and 140,000 numbers refer to customer hours (minutes?) of interruption. If not, please clarify.

RESPONSE:

The numbers 280,000 and 140,000 on Page 2 of Exhibit 2B, Section E6.2 refer to customer hours of interruption.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 101:

Reference(s): Exhibit 2B, Section E6.2, p. 2

Please provide the total kms of underground cable and overhead cable on THESL's system, separate numbers for jacketed and un-jacketed, and of the underground portion and for each of underground and overhead cable, what amounts of the various types of cable are in use. Please indicate circuit/km of direct buried XLPE, direct buried other cable (and type) contained in PVC ducts, contained in concrete ducts (separate numbers for jacketed and un-jacketed, contained in some other way, and in each case, describe the amount of each type of cable used. Finally, please distinguish "km of cable" from "circuit/km of cable".

RESPONSE:

For Overhead total conductor length please refer to Exhibit 2B, Section D2.2.1. The total circuit length of Underground Jacketed Cable is 2,094 kms. The total circuit length of Underground Unjacketed Cable is 1,426 kms.

Please see Table 1 below showing Underground Cable Quantities in various installations and Table 2 showing the quantity of XLPE and other direct buried cable:
### Table 2: Cable Quantities in various Installations (Horseshoe UG System)

<table>
<thead>
<tr>
<th>Cable Construction Type</th>
<th>Jacketed /Unjacketed</th>
<th>Jacketed</th>
<th>Unjacketed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Conduct or Length (km)</td>
<td>Sum Conduct or Length (km)</td>
<td>Total Circuit Length (km)</td>
</tr>
<tr>
<td>Concrete-Encased Duct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacketed</td>
<td>XLPE</td>
<td>237</td>
<td>3317</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>3057</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Unjacketed</td>
<td>XLPE</td>
<td>1678</td>
<td>2441</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>763</td>
<td></td>
</tr>
<tr>
<td>Direct Buried Duct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacketed</td>
<td>XLPE</td>
<td>12</td>
<td>396</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>379</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Unjacketed</td>
<td>XLPE</td>
<td>190</td>
<td>266</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Direct Buried</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacketed</td>
<td>XLPE</td>
<td>50</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Unjacketed</td>
<td>XLPE</td>
<td>303</td>
<td>377</td>
</tr>
<tr>
<td></td>
<td>TRXLPE</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>74</td>
<td></td>
</tr>
</tbody>
</table>
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 102:
Reference(s): Exhibit 2B, Section E6.2, p. 3

Please confirm that the XLPE cable proposed to be replaced is all un-jacketed. If not, please provide amounts for each.

RESPONSE:
The XLPE cable proposed to be replaced is a combination of jacketed and un-jacketed cable. The estimated amounts for each type are as follows:

i. XLPE jacketed – 114 circuit kilometres

ii. XLPE unjacketed – 101 circuit kilometres
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 103:
Reference(s): Exhibit 2B, DSP (General)

a) Within each of the revised programs, eg. "Underground System Renewal", the plan identifies a number of projects or priority areas for work. The plan also provides the forecast annual expenditures for each program over the plan term. BOMA requests that within each program, and for each year 2020, 2021, 2022, 2023, 2024, THESL (i) identify the project that will be undertaken; (ii) prioritize the projects. BOMA's objective is to have a single, prioritized list for all system renewal projects, regardless of the "program" they fall into.

b) Please prioritize among the programs themselves, eg. underground, horseshoe, underground, downtown, etc. BOMA assumes that, in the event it was not allocated all the resources it asked for, THESL would not likely eliminate a program in its entirety but would defer or cancel some projects in many of the programs.

c) BOMA would also request that projects in all four (4) categories be prioritized in a single list. BOMA understands that the higher priority projects would be those that are required by law, including the Distribution System Code, and in respect of which THESL has no or very little discretion. After the mandatory projects, BOMA would like to see the priorities among the remaining projects in the various programs. Please note that BOMA would consider a response that all our projects are of equal priority, necessary, etc. to be unresponsive. Other major utilities, such as Alectra, have provided ranked project priority lists.
RESPONSE:
a) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b).
b) Please refer to Toronto Hydro’s response to interrogatory 2A-AMPCO-16 part (b).
c) Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-36 part (b).
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 104:

Reference(s): Exhibit 2B, Section E6.2, p. 19

Please provide a copy of the City of Toronto's Sewer Use By-law. Have there been any prosecutions under the by-law for oil containing PCB leaks?

RESPONSE:

City of Toronto’s Sewer Use By-Law:


There have been no prosecutions under the by-law for leaks of oil containing PCBs for Toronto Hydro.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 105:
Reference(s): Exhibit 2B, Section E6.2, p. 22

Please provide data on the 5,000 underground switches. How many are air-vented vs. sealed with SF6 insulation? How many are in vaults vs. pad-mounted?

RESPONSE:
Please refer to Exhibit 2B, Section E6.2, Page 25, Figure 20 the age distribution of total number of switches in the THESL’s underground system (Horseshoe). Table 1 below provides the breakdown of pad-mounted and vault installed switches based on insulation type.

Table 1: Count of Underground switch by type

<table>
<thead>
<tr>
<th>Installation Type</th>
<th>Insulation Type</th>
<th>Air</th>
<th>SF6 Insulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pad Mounted</td>
<td></td>
<td>578</td>
<td>527</td>
</tr>
<tr>
<td>Vault</td>
<td></td>
<td>4263</td>
<td>106</td>
</tr>
</tbody>
</table>
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 106:
Reference(s): Exhibit 2B, Section E6.2, p. 27

Please describe the improvements THESL made of its inspection forms and processes.

RESPONSE:
Toronto Hydro has improved inspection forms and processes to capture more detailed information about the condition of assets during an inspection. This allows Toronto Hydro to make more informed decisions on the appropriate corrective actions and prioritization of deficiencies reported, and ultimately to mitigate risks associated with the distribution system.

Areas of improvement included observations related to corrosion, oil deficiencies, infrared thermography, and partial discharge. A specific example is oil deficiencies for submersible transformers, which elevate the risk of oil entering the environment due to the asset typically being installed close to or above vault drains. Inspectors now capture, in a very standardized manner, information which includes:

- Whether the oil deficiency is active or not;
- The volume of the oil that may have leaked;
- Whether the oil contains PCBs;
- The location of the oil deficiency;
- Whether the oil has entered the environment; and
- Photographs of the deficiency.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 107:

Reference(s): Exhibit 2B, Section E6.2, p. 26

Please discuss whether technology is available, other than conversion to sealed SF6 switches to protect air-vent insulated switches from deterioration.

RESPONSE:

The design of air-insulated switches consists of components including insulators, mechanical springs and electrical contacts that are exposed to the external environment. This exposure leaves the switchgear and related components vulnerable to contaminants which lead to premature equipment deterioration and failure. Without sealing or pressurizing the internal switch mechanisms, there is no proven or reliable technology that can be applied to prevent premature deterioration and failure in a contaminated environment.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 108:
Reference(s): Exhibit 2B, Section E6.2, p. 28

What progress has THESL made to move the estimating process downstream, after detailed design has commenced, with less reliance on necessarily inaccurate high level estimates? See, for example issues of HONI Distribution in its most recent case.

RESPONSE:
An overview of Toronto Hydro’s estimating practices for capital projects can be found at Exhibit 2B, Sections D1.2.2 and D1.2.3. As described in this and previous rate-applications, Toronto Hydro planners create high-level estimates during the development of high-level project scopes of work, and specialized design staff create detailed design estimates closer to the time of project execution.

Additionally, beginning between 2014 and 2015, Toronto Hydro introduced an intermediate Project Development function to improve the quality and consistency of budgetary estimates and scope packages prior to the detailed design phase, as well as to continuously capture and implement lessons learned from variances between planned estimates and final construction costs. The Project Development stage of planning is discussed in Exhibit 2B, Section D1.2.2 and in Exhibit 4A, Tab 2, Schedule 9.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 109:

Reference(s): Exhibit 2B, Section E6.2, p. 29

Are all of the undisposed area projects focused exclusively on direct buried XLPE cable, or on voltage upgrades (eleven (11) feeders of sixty-nine (69) feeders). Is each of the sixty-nine (69) feeders on which work will be performed XLPE direct buried? Please explain.

RESPONSE:

All 69 feeders on which work is proposed for the 2020-2024 period have sections of legacy XLPE cable. The trigger driver for every project in this program is the failure risk associated with aging, deteriorating and obsolete underground equipment, including high-risk XLPE cable. As explained at Exhibit 2B, Section E6.2.4.2, 11 of the 69 feeders that Toronto Hydro has prioritized for renewal during the period also require voltage conversion.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 110:

Reference(s): Exhibit 2B, Section E6.3, p. 2

Have all the PILC levels and piece-out program been removed?

RESPONSE:

Please refer to Exhibit 2B, Section E4, page 10, lines 16-23.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 111:
Reference(s): Exhibit 2B, Section E6.3, p. 2

Please elaborate on, and provide the basis for this sentence:

"To manage the pacing of investments in this segment, Toronto Hydro has begun to predict with increasing accuracy and precision the cable segment at the highest risk of failure".

RESPONSE:
As explained further in Exhibit 2B, Section E6.3, at page 6, Toronto Hydro has developed a statistical method to prioritize primary cable segments to improve reliability. Various factors, including historical failures, number of splices on feeders, age, customer base, and test results are included in this method.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION INTERROGATORIES

INTERROGATORY 112:
Reference(s): Exhibit 2B, Section E6.3, p. 3

Please provide the total circuit/km of underground cable in the downtown area serving:

a) the financial and other commercial buildings;

b) the residential buildings including condominiums and apartment buildings;

c) the amount (and percentage) of (a) and (b) cable that is PILC, the amount that is "standard tree retardant or cross-linked polyethylene cable".

RESPONSE:

a) Toronto Hydro is unable to precisely segregate circuit kilometres in the downtown area as requested. The majority of feeders in the downtown area serve a combination of commercial and residential buildings and therefore, the cables that make up those feeders jointly serve both types of customer premises. Toronto Hydro estimates that approximately two thirds of the circuit kilometres in the downtown area serve these loads jointly. Toronto Hydro estimates, that approximately one quarter of the circuit kilometres serve commercial load solely.

b) Please see response to part (a) above. Toronto Hydro estimates that approximately 5% of the circuit kilometres in the downtown area serve residential load.
c) Toronto Hydro is unable to provide the breakdown requested. In addition to the fact that the majority of feeders service commercial and residential buildings jointly, the analysis is further complicated by the fact that feeders contain combinations of PILC and XLPE cable.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 113:
Reference(s): Exhibit 2B, Section E6.3, p. 4

a) How many km of PILC cable contain PCB containing oil?

b) Please confirm that only PILC cable in HIS condition are being removed in the program.

RESPONSE:

a) Toronto Hydro estimates approximately 275 kilometres of cable segments contain greater than 2 ppm of PCB.

b) Toronto Hydro does not calculate health index scores for PILC cables. For a detailed discussion of the multi-faceted analysis Toronto Hydro undertakes to identify and prioritize only the highest-risk PILC cables for replacement, please refer to Exhibit 2B, Section E6.3.3.1.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION

INTERROGATORIES

INTERROGATORY 114:

Reference(s): Exhibit 2B, Section E6.3, p. 6

Please define primary cable and secondary cable in the downtown core.

RESPONSE:

In the downtown core, primary cables have an operating voltage of 13.8 kV or 4.16 kV and are mostly Paper Insulated Lead Covered (“PILC”) or Cross-linked Polyethylene (“XLPE”) cables. Secondary cables are rated at an operating voltage of 120/208V or 240/416V, and comprise mostly of XLPE and Asbestos Insulated Lead Covered (“AILC”) cables.
RESPONSES TO BUILDING OWNERS AND MANAGERS ASSOCIATION
INTERROGATORIES

INTERROGATORY 115:

Reference(s): Exhibit 2B, Section E6.3, p. 11

How many oil leaks are currently occurring for the underground PILC/lead cable?
Approximately how many additional leaks start each year?

RESPONSE:

Toronto Hydro does not currently have any active leakers in its system. The amount of
cables that leak each year varies. Historically, Toronto Hydro has identified an average of
15 leaking cable joints on PILC segments per year. These leakers are addressed reactively
or through existing planned capital work.
RESPONSES TO CONSUMERS COUNCIL OF CANADA INTERROGATORIES

INTERROGATORY 30:

Reference(s): Exhibit 2B, Section A2

Please indicate when THESL starting using the “trigger driver” approach to its capital planning. What was the impetus for adopting this approach?

RESPONSE:

Toronto Hydro started using the “trigger driver” approach to its capital planning during the development of the 2015-2019 Rate Application (EB-2014-0116), in accordance with the Chapter 5 – Consolidated Distribution System Plans Filing Requirements, which were issued by the OEB on March 28, 2013.
RESPONSES TO CONSUMERS COUNCIL OF CANADA INTERROGATORIES

INTERROGATORY 31:

Reference(s): Exhibit 2B, Section A3

Please provide a detailed timeline for the development of THESLs’ DSP.

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-34 for a detailed timeline of the development of Toronto Hydro’s Distribution System Plan.
RESPONSES TO DISTRIBUTED RESOURCE COALITION INTERROGATORIES

INTERROGATORY 7:
Reference(s): Exhibit 2B, Section D, Appendix D

a) Please identify any and all instances in which electrification, electric mobility, EVs, and electrified transportation charging were included or considered as mitigating or aggravating factors in THESL's Climate Change Vulnerability Assessment.

RESPONSE:

a) There were no such instances.
RESPONSES TO DISTRIBUTED RESOURCE COALITION INTERROGATORIES

INTERROGATORY 8:
Reference(s): Exhibit 2B, Section B
Exhibit 2B, Section B, Appendix E

Preamble:
The Central Toronto Area Integrated Regional Resource Plan (the IRRP) prepared by the IESO on behalf of the Central Toronto Area Working Group (which includes THESL) identifies the following key considerations related to planning for long-term needs:

- Recent trends (including policy changes supporting distributed generation) are changing the landscape for regional electricity planning. "Traditional", wire-based approaches to electricity planning may not be the best fit for all communities (page 85).

- The "community self-sufficiency" approach to regional electricity planning places emphasis on meeting community needs largely with local, distributed resources, which include, *inter alia*, demand response, distributed generation and storage, smart grid technologies, and EVs (page 86).

- Integrated energy planning at the community level provides an opportunity for broader consideration of land-use, development and growth, infrastructure requirements, and technology solutions that include, *inter alia*, energy storage technologies, battery EV storage capabilities (especially for load intensification cluster applications), micro-grid and micro-generation capabilities (page 90).

- There is a strong community interest in the "community self-sufficiency" approach to planning (page 89).
THESL notes that its DSP has been informed by the results of the completed regional plans and continues to coordinate with the IESO and Hydro One Networks Inc. with respect to plans that are under development.

a) Please explain how THESL's DSP has been informed by the "community self-sufficiency" approach to regional electricity planning, as discussed in the IRRP, including the extent to which THESL has considered the capacity of EVs, "prosumers", and other DERs to meet integrated energy planning needs.

b) Please describe all measures that THESL is undertaking to facilitate the integration of EVs, "prosumers", and other DERs in its energy planning and business planning processes.

RESPONSE:

a) Toronto Hydro’s DSP includes a number of investments which are aligned with the “community sufficiency approach” discussed in the IRRP, and which support the Conservation First Framework, the connection of renewable energy generation (REG), and the use of distributed generation (DG) to meet long-term energy planning needs. These investments are summarized below. For more information, please refer to the evidence cited:

- The Energy Storage program (Exhibit 2B, Section E7.2) includes plans to use energy storage systems (ESS), which are non-wires solutions, to enhance grid performance, remediate power quality problems (e.g. voltage sags), improve reliability in problem areas, increase the capacity of feeders at peak periods, and enable the connection of renewables.
b) Please refer to the response provided above, as well as Toronto Hydro’s responses to interrogatories 1B-DRC-2(b) and 1C-DRC-6 which address the use of EVs and DERs in enhancing reliability and managing asset integrity risk, respectively.
RESPONSES TO DISTRIBUTED RESOURCE COALITION INTERROGATORIES

INTERROGATORY 9:

Reference(s): Exhibit 2B, Section E7.2

Preamble:

THESL's proposed Energy Storage Systems (ESS) Program includes "renewable enabling" ESS investments, which are distribution investments that support the growth of distributed renewable generation on the system that in turn offset generation and transmission investments. THESL acknowledges that ESS can cost-effectively enable EVs to connect to the distribution system by addressing localized system constraints. However, THESL does not propose any EV ESS projects at this time.

a) Please indicate whether EV batteries are expressly and/or implicitly, included in THESL's definition of "Energy Storage Systems" and, if so, how?

b) Please explain how THESL proposes to optimize efficiencies from the many EV batteries and charging infrastructure in its systems?

c) Please itemize all of the benefits that an EV ESS may have and provide THESL's rationale for not pursuing any EV ESS projects at this time given the stated benefits.

RESPONSE:

a) EV batteries are not included in Toronto Hydro’s definition of Energy Storage Systems.
b) Toronto Hydro does not currently have such a proposal. Toronto Hydro continues to monitor the development of EV technology and its effect on the safety and reliability of the distribution system.

c) Please see the response to part (b) above.
RESPONSES TO DISTRIBUTED RESOURCE COALITION INTERROGATORIES

INTERROGATORY 10:

Reference(s):

Exhibit 2B, Section E7.4
Exhibit 3, Tab 1, Schedule 1, p. 10

Preamble:

THESL notes that impacts of EVs and distributed generation on overall loads and demands on the system have not been determined to be material. THESL states that it does not have enough information about these markets to be able to confidently include any impacts on loads or demands and there has been no explicit incorporation of the potential load impacts in the load forecast, other than trends that would be part of measured loads to date, and would be captured in the multivariate regression models.

THESL’s Stations Expansion program addresses medium- to long-term system capacity needs. One of the segments of the program will expand the capacity of the Copeland TS located in Toronto’s financial district, providing additional capacity of 144 MVA. The importance of the Copeland TS expansion is framed in the context of THESL’s load forecasting for the area. However, THESL notes that the impact of EV deployment has not been accounted for in its forecast.

Further, THESL states that, following the release of the LTEP in the fall of 2017, THESL is working with regional planning stakeholders to develop a 25 year load forecast that includes an assessment of different EV deployment scenarios. Large-scale EV deployment may increase the peak load demand at certain stations, thus triggering the need for additional capacity.
a) Please provide the 25 year load forecast that includes an assessment of different EV deployment scenarios referenced at Exhibit 2B, Section E7.4, page 10. Please provide any and all EV-related data that THESL relied upon in support of the conclusions above and the load forecast. If the load forecast is not available, please provide an update as to its status and its expected date of completion.

b) Please provide, in the chart format below, an assessment of the impacts on loads and demands — including the load forecast for the 2020-2024 period — of your estimate of EVs and distributed generation in each of the years of the CIR and any supporting references.

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVs (number, kWh)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>EV infrastructure (number, kWh)</td>
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<tr>
<td>DERs (number, type, kWh)</td>
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</table>

| etc. |      |      |      |      |      |


c) In the recently released Made-in-Ontario Environment Plan (the Environment Plan; see Attachment 1), the Ministry of Environment, Conservation and Parks estimates that 16% of targeted greenhouse gas emissions reductions will come from low carbon vehicles (i.e., primarily EV adoption. Please indicate:

i) whether THESL's assumptions regarding EVs are consistent with this;

ii) if not, what were THESL's assumptions;

iii) whether THESL has reconsidered the impact of EV adoption on load forecasts in light of the Environment Plan;

iv) whether THESL will update its EV assumptions in light of the Environment Plan;
v) what are the estimated total capital expenditures and operating expenditures regarding EV charging infrastructure that THESL has included in the application and for each year;

vi) what capital expenditure and operating expenditure funding (federal, provincial, or otherwise) is available to THESL specific to EVs and DERs.

d) Please explain whether THESL's load forecasts are consistent with and take into account EV adoption rates expected under the Environment Plan.

RESPONSE:

a) As set out in Exhibit 2B, Section B2.1, the planning process that produces the load forecast referred to in Exhibit 2B, Section E7.4 is ongoing and expected to conclude in the fall of 2019.

b) The forecasted generation connections in number and capacity for the period 2020-2024 can be found in Table 6 and Table 7 in Exhibit 2B, Section E5.1.

With respect to EVs, please refer to Toronto Hydro’s response to interrogatory 1C-DRC-6.

c)

i) The Government’s Environment Plan does not include an EV adoption forecast for the City of Toronto.

ii) Please see Toronto Hydro’s response to part (a) with respect to regional planning.

Please refer to Toronto Hydro’s response to interrogatory 1C-DRC-6 with respect to more localized planning.
iii) Please see Toronto Hydro’s response to part (c)(i).

iv) Please see Toronto Hydro’s response to part (c)(i).

v) Please refer to Toronto Hydro’s response to interrogatory 1C-EP-16 (c).

vi) As a distributor, Toronto Hydro is eligible to apply for a host of different federal, provincial, and other funding programs related to EVs. For example, Toronto Hydro received funding through the Workplace Electric Vehicle Charging Incentive Program through the Ministry of Transportation. With respect to DERs, Toronto Hydro is able to recover costs in accordance with O.Reg. 330/09 – Provincial Rate Protection.

d) Please see Toronto Hydro’s response to part (c)(i).
RESPONSES TO DISTRIBUTED RESOURCE COALITION INTERROGATORIES

INTERROGATORY 11:

Reference(s):
Exhibit 2B, E8.1
Exhibit 2B, E8.1, Appendix A
Exhibit 4A, Tab 2, Schedule 7

Preamble:

THESL states that control centres support the new smart grid ecosystem, comprising renewable and other DERs, micro-grids, EVs, and growing interest in energy storage on the system for power quality, off-peak storage, and grid resilience.

THESL also acknowledges that there are externally driven factors that will likely increase the volume or complexity of control centre activities, including increased market penetration of distributed generation, EVs and charging stations, and energy storage.

a) Please provide, directionally if there is no supporting data, THESL's assessment of how each of these factors will impact the volume or complexity of control centre actions:

i) increased market penetration of distributed generation;

ii) EVs;

iii) EV charging stations;

iv) energy storage (and please indicate if EV batteries are included in your assessment of energy storage).
RESPONSE:

a) The fundamental change in Control Centre operations as a result of the new smart grid ecosystem is a shift towards the management of bi-directional power flow and the resulting practices and procedures required to safeguard the public, field crews, the grid, and grid-connected equipment (e.g. customer equipment). A directional summary of some specific anticipated impacts follows in Table 1.

<table>
<thead>
<tr>
<th>Factor</th>
<th>General Impact to Complexity / Volume of Control Centre Actions</th>
</tr>
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</table>
| Increased market penetration of distributed generation | • With the forecasted increase of distributed generation connections of 800MW by the end of 2024, there is a need for detailed monitoring and control capabilities within Control Centre operational systems in order to ensure that operators are able to safeguard, manage and control the distribution system in a manner that maximizes operational resilience.  
• Ensure the safety of workers through adequate work practices, proper application of the work protection code and field procedures, etc. Isolating sections of the distribution system for planned work will become more complex as they need to account for an increase of the number of energy sources.  
• Additional energy sources increases the number of options for outage restoration, particularly if islanding certain areas is a technically acceptable option in certain circumstances.  
• Evolving customer service needs as customers that supply energy to the grid have unique expectations. As it relates to planned and unplanned outages, they may be losing out on potential revenue and/or require direct coordination with the utility Control Centre in order to safely synchronize to the grid. Local protection and control schemes may need to be continually monitored and addressed on a case by case basis. This currently exists with many distributed generation sites connected to the Toronto Hydro grid.  
• Short circuit levels are more dynamic and require active monitoring to ensure that the overall circuit is operated within short circuit limits.  
• Providing stable load during restoration of bulk system outages. |

Table 1: General Impact to Complexity/Volume of Control Centre Actions
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<tr>
<th>Factor</th>
<th>General Impact to Complexity / Volume of Control Centre Actions</th>
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</table>
| Electric vehicles (including electric vehicle batteries and electric vehicle charging stations) | • Similar impacts as stated for distributed generation resources (see above).  
• Electric vehicles can feed excess power back to the grid.  
• Mobility of electric vehicles can result in more volatility in local electricity demand (vehicles will be connected to different circuits depending on what charging stations they’re using at a given point in time). |
| Energy storage                                                       | • Similar impacts as stated for distributed generation resources (see above).  
• Management of microgrids may require active management particularly following a loss of utility supply.  
• Increased coordination with microgrid owners and/or operators. For example, charging, discharging and dispatch scheduling.  
• Optimized operation of an energy storage system will require knowledge of the current and forecasted operating conditions at the utility level, and/or may require direct coordination with the utility operators. |
INTERROGATORY 32:
Reference(s): Exhibit 2B, Section C2.3, Table 4

Preamble:
“Between 2013 and 2017 outages caused by defective equipment was the main
ccontributor to SAIDI and SAI FI performance. As Figures 6 and 7, demonstrate, there was a
slight improvement in the level of reliability in these years. This is directly attributable to
Toronto Hydro’s efforts to address aging and obsolete assets”.

a) Please provide for SAIDI and SAI FI, the average interruption cause codes for the 5
year period 2013-2017. Specifically indicate the percentages related to defective
equipment. In addition to defective equipment list in declining order, the other
contributors to interruptions/ outages.

b) If available, please provide the percentage of interruptions related to each of
transformation and lines and compare to defective equipment total.

c) In EB-2013-0116 TH indicated it would monitor Momentary Interruptions. Please
provide, in summary and chart form, the MAIFI data for the 5 years 2013-2017.

d) What are the cause codes for MAIFI? Please provide these in Table and Pie Chart
form.
e) What measures/level of investment 2020 -2024 is aimed at maintaining/improving MAIFI?

**RESPONSE:**

a) Please see Table 2 of Exhibit 1B, Tab 2, Schedule 4 at page 11.

b) Please see Sections 9.1, 9.2 and 10 in Exhibit 1B, Tab 2, Schedule 4 at pages 17-21.

c) Please see Figure 2 in Exhibit 1B, Tab 2, Schedule 2 at page 18.

d) Please see Table 1 and Figure 1 below.

**Table 1: MAIFI Cause Codes**

<table>
<thead>
<tr>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>ADVERSE ENVIRONMENT</td>
<td>0.00</td>
<td>0.01</td>
<td>0.06</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
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<tr>
<td>ADVERSE WEATHER</td>
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<td>0.23</td>
<td>0.19</td>
<td>0.15</td>
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<tr>
<td>DEFECTIVE EQUIPMENT</td>
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<td>0.37</td>
<td>0.36</td>
<td>0.27</td>
<td>0.40</td>
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<td>FOREIGN INTERFERENCE</td>
<td>0.24</td>
<td>0.26</td>
<td>0.21</td>
<td>0.24</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>HUMAN ELEMENT</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>LIGHTNING</td>
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<td>0.05</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>LOSS OF SUPPLY</td>
<td>0.04</td>
<td>0.00</td>
<td>0.04</td>
<td>0.01</td>
<td>0.10</td>
<td>0.04</td>
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<td>TREE CONTACTS</td>
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<td>0.05</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>UNKNOWN</td>
<td>1.17</td>
<td>1.50</td>
<td>1.74</td>
<td>1.74</td>
<td>1.68</td>
<td>1.57</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>2.37</td>
<td>2.55</td>
<td>2.72</td>
<td>2.64</td>
<td>2.52</td>
<td>2.56</td>
</tr>
</tbody>
</table>
e) Please refer to Toronto Hydro’s response to interrogatory 1B-EP-4 (c)(ii).
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION
INTERROGATORIES

INTERROGATORY 33:
Reference(s): Exhibit 2B, Section C2.3, Table 4, and Figures 6&7

Preamble:
Toronto Hydro states its proposed investments during the 2020-2024 plan period, are aimed at improving asset condition and demographics in order to mitigate reliability risks associated with defective equipment. Reliability results, as measured by SAIDI and SAIFI-Defective Equipment, are expected to decrease if the requisite investments are not made.

a) How much is invested to achieve each of the 4 reliability goals in the Reliability Scorecard? Please provide the linkage to investment and estimated 5-year cumulative amounts for each.

b) Confirm that according to PSEs Benchmarking Study, TH SAIFI is above that of the peer group.

c) Please provide the levels in # hours/customer for the Peer group and TH.

d) Why is maintaining SAIFI and SAIDI an appropriate Goal for 2020-2024 What investment levels were examined? Please provide the data and discussion.

e) What is TH’s Strategy and Goal to address momentary interruptions (MAIFI) in the CIR period? Please discuss.
RESPONSE:

a) All programs driven by “Failure”, “Failure Risk”, “Reliability”, or “Functional Obsolescence” will help achieve the four reliability goals. Within these programs, asset replacements, system upgrades, and reconfigurations will help to improve reliability. This represents the majority of spending within the System Renewal category (discussed in Exhibit 2B, Section E4.2.2, Table 4) and the System Service category (discussed in Exhibit 2B, Section E4.2.3, Table 5).

In addition, programs that do not have these drivers but contribute to the “Reliability” outcome, as identified in the outcomes tables at the beginning of each expenditure program, are also expected to contribute to reliability goals. This includes various programs within System Access (discussed in Exhibit 2B, Section E5), System Service (Exhibit 2B, Section E7), General Plant (Exhibit 2B, Section E8) and also OM&A programs (Exhibit 4A, Tab 2).

Many of the aforementioned programs have additional drivers besides reliability (e.g. safety) and contribute to more than one outcome (e.g. reliability and environment). For this reason, it is not possible for Toronto Hydro to create a simple one-to-one relationship between the proposed amounts invested and the four reliability measures.

b) PSE’s econometric reliability benchmarking analysis resulted in a finding that Toronto Hydro’s historical SAIFI metrics are higher than the benchmark SAIFI values.¹

¹ EB-2018-0165, Exhibit 1B, Tab 4, Schedule 2, Page 9.
c) Please refer to the PSE working papers in the Excel spreadsheet, “Modeling Dataset.xls”. Column BF contains the SAIDI values for the entire sample, including Toronto Hydro. The values are in minutes; dividing by 60 will convert them to hourly values.

d) Toronto Hydro’s objective of maintaining SAIFI and SAIDI over the 2020-2024 period is one of a balanced set of strategic objectives that was informed by, and aligns with, customer preferences identified during the utility’s extensive and iterative Customer Engagement activities for this application. Exhibit 2B, Section E2, provides a full discussion of this topic, including a summary of the investment levels considered.

e) An overview of how Toronto Hydro’s plan aligns with customers’ needs and preferences for reliability – including power quality and momentary interruptions – can be found at Exhibit 2B, Section E2.3.1.1, page 49. In addition to the specific initiatives mentioned therein, Toronto Hydro expects many of its planned reliability investments in various System Renewal and Service programs to support improvements in both sustained and momentary outages.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 34:
Reference(s): Exhibit 2B, Section C2.3, Table 4, and Figures 8 & 9

Preamble:
For the 2020-2024 plan period, Toronto Hydro expects to improve performance for FESI-7 System measure and maintain performance for FESI-6 Large Customers.

a) Why is improving FESI-7 but not FESI-6 an appropriate strategy? Please discuss.

b) In addition to # feeders please provide the # customers and loads associated with each goal.

c) Please provide the estimated 5 year investments for achieving the FESI-7 and FESI-6 goals.

RESPONSE:

a) The FESI-6 Large Customers measure is by definition a higher standard of performance than the FESI-7 System measure. In light of this, as well as the strong recent performance of the measure, Toronto Hydro chose not to prioritize further improvements to FESI-6 Large Customers over other important customer-focused outcome objectives.
b) The specific feeders on the FESI-6 and FESI-7 lists change as feeder level performance improves or deteriorates over time. Furthermore, the number of customers and the amount load varies from feeder to feeder. Therefore, Toronto Hydro cannot associate a specific number of customers and loads with a future FESI objective.

c) The Worst Performing Feeder segment in the Reactive and Corrective Capital program (Exhibit 2B, Section E6.7) is a targeted contributor to achieving the FESI-7 and FESI-6 Large Customers performance outcomes. More broadly, many of the utility’s reliability-supporting capital programs are expected to contribute to achieving FESI performance outcomes over the five-year plan period. Toronto Hydro uses a combination of historical reliability analysis and leading indicators of asset performance to identify and prioritizing System Renewal and System Service investments that will contribute to long-term improvements to current FESI feeders and mitigate the risk of other feeders joining the FESI list. Please refer to Toronto Hydro’s response to interrogatory 2B-EP-33(a) for details on programs supporting reliability outcome objectives.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION
INTERROGATORIES

INTERROGATORY 35:
Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment

a) Did Toronto Hydro issue an RFP for this report? If it did, please file it. If it did not please explain why?

b) What was the cost of this report and is Toronto Hydro seeking OEB approval to recover it from ratepayers? If Toronto Hydro is seeking to recover the cost from ratepayers please explain the recovery mechanism and the recovery period.

c) Did Toronto Hydro issue a statement of work, terms of reference, engagement letter or any other similar document that described the purpose and the scope of the report to the consultants who prepared the report? If the answer is yes, please file all such documents. If the answer is no, please explain why.

RESPONSE:

a) No, Toronto Hydro did not issue an RFP for this report. The study was initiated by the Clean Air Partnership and completed with support from Natural Resources Canada and Toronto Region's Weatherwise Partnership. Toronto Hydro participated in the study by providing information and data.
b) Toronto Hydro contributed to this study with an in-kind contribution. There are no further costs associated with this study being proposed in this Application. See attached Appendix A.

c) Please see attached Appendix A for Toronto Hydro’s engagement letter. Please refer to Toronto Hydro’s response to interrogatory 2B-EP-43(b) for a slide deck, which outlines the scope of the work of the study.
June 27, 2013

Kevin Behan,
Deputy Director
Clean Air Partnership
75 Elizabeth St.
Toronto, ON M5G 1P4

Dear Mr. Behan,

In my role as Vice President, Asset Management at Toronto Hydro, I agree to support the Clean Air Partnership in the proposed project entitled: *Climate Change Risk Assessment of Toronto Hydro Electrical Distribution Infrastructure*, under Call for Proposal Section 4.1 – Climate Change Impacts Risk and Opportunity Assessments. Toronto Hydro Electric System Ltd (Toronto Hydro) has a strong interest in the outcome of the project. Toronto Hydro will be contributing approximately $84,000 in-kind support which is equivalent to 91 person-days of staff time and software/printing support over the course of the project.

Toronto Hydro has asked the Clean Air Partnership (CAP) to be the client and contracting legal entity to submit a proposal to deliver this project. The proposed project would be managed by CAP, a well-known Toronto-based organization that Toronto Hydro has collaborated with in the past. We have every confidence in their ability to complete this project on-time and on-budget.

The Clean Air Partnership has had previous experience in developing adaptation projects and has extensive networks across Canada that can help bring awareness to the value of this project, once it’s completed. The partners on this proposed project are organizations Toronto Hydro is very familiar with and that we partner with not only at the WeatherWise Partnership, but on sector-wide capital infrastructure planning initiatives within the Toronto area.

We are also members of the Canadian Electricity Association, and other Ontario-based electricity organizations, where we believe there would be considerable interest among the members in this kind of proposal and most importantly in the practical outcomes that will result from the funding.

Should you have any questions or you need any more information, please do not hesitate to contact me at: 416 542 2841.

Sincerely,

Ivano Labricciosa
Vice President, Asset Management
Toronto Hydro-Electric System Limited
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 36:

Reference(s): Exhibit 2B, Section D, Appendix D, p. 7

Preamble:

“The probability of a climate parameter occurring during the study period was determined using global climate modelling (GCM) data obtained from the Intergovernmental Panel on Climate Change’s 5th Assessment Report (IPCC AR5). In many cases, this information was validated or refined through the use of regional climate modelling data, statistical downscaling and climate analogues.”

a) What is global climate modelling data?

b) How and why was it validated and refined?

c) What is regional climate modelling data?

d) What is statistical downscaling?

e) What are climate analogues?
RESPONSE:

a) Please refer to Exhibit 2B, Section D, Appendix D, Appendix B – Background Information on Developing Climate Data, Section B.3.2.1 and Table B1.

b) Please refer to Exhibit 2B, Section D, Appendix D, Appendix B – Background Information on Developing Climate Data, Section B.3.3.2 – Complex Climate Events: Regional Climate Models and other projection techniques.

c) Please see response to part (b).

d) Please see response to part (b).

e) Please see response to part (b).
**RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION**

**INTERROGATORIES**

**INTERROGATORY 37:**

Reference(s): Exhibit 2B, Section D, Appendix D, p. 8, Table ES-1

(a) Which period is covered by the term “historical” used in the table?

(b) Please provide years and source of information for each historical parameter.

(c) Considering that this application deals with the 2020 to 2024 period why is there no specific forecast for that period?

**RESPONSE:**

(a) Please refer to Exhibit 2B, Section D, Appendix D, Appendix B – Background Information on Developing Climate Data, Section B.3.1 “Historical Climate Observations”.

(b) Please see response to part (a).

(c) The study was not commissioned for the purpose of developing this rate application.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 38:

Reference(s): Exhibit 2B, Section D, Appendix D, Original, p. 9, Figure ES-1

a) Why is the risk of freezing rain lower in the former City of Toronto than in the former Borough of East York?

b) Why is the risk of lightning significantly lower in the former City of Toronto?

c) Why is the risk of high ambient temperatures highest in High Park?

RESPONSE (PREPARED BY AECOM/RSI):

a) As identified in the Risk Assessment Matrix, stations in the Former Toronto area are primarily indoors and therefore not exposed to certain changes in climate parameter, including freezing rain and lightning. As noted in the AECOM report, “where there were no interactions between climate and infrastructure, asset representations were coloured in grey. Finally, white spaces within the City of Toronto generally indicate where no electrical service is provided.”

b) See response to (a) above.

c) As indicated in the AECOM report, “Vulnerabilities from high heat events stem primarily from projected available station capacity by the 2050s.”

Panel: Distribution System Capital and Maintenance
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION INTERROGATORIES

INTERROGATORY 39:
Reference(s): Exhibit 2B, Section D, Appendix D, p. 15

Preamble:
“The evaluation was carried out for the study period (2015 to 2050), but with specific focus on the possible state of the electrical system at the 2030’s and 2050’s time horizons.”

Considering that three years in that period, 2015, 2016 and 2017 are now in the past and a fourth year, 2018, is almost over, please provide the predictions of the authors for those years with actual results of all parameters listed in Table ES-1. If the authors are unable to provide the comparison, please explain why not and provide a detail explanation for your answer.

RESPONSE (PREPARED BY AECOM/RSI):
The baseline period is set to a 30-year average of the most recent record finishing in a year ending with “0” (i.e. 1981-2010), as is best practice adopted by ECCC and recommended by the World Meteorological Organisation (WMO). Please see WMO Guidelines on the Calculation of Climate Normals – 2017, WMO #1203.

It is important to note that models produce ‘projections’ not ‘predictions’ of exact years into the future. Therefore, it should never be expected that a year to year match between observations and model output over the four years suggested would be found.
State of the art climate models are not able to ‘predict’ weather at this interval and will not be able to in the foreseeable future.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 40:
Reference(s): Exhibit 2B, Section D, Appendix D, Table 2-2, p. 16

a) Table 2-2 shows projected loads in 2030’s and 2050’s. Why are current loads not shown for comparison?

b) Please expand the table to show current loads.

c) What do the 2030’s and 2050’s mean? Are these projected loads for the beginning, midpoint or end of these two decades? Why are 2020’s and 2040’s not shown?

RESPONSE (PREPARED BY TORONTO HYDRO):

a) As specified in Exhibit 2B, Section D, Appendix D, section 2.9, page 15; the study specifically focused on the state of the electrical system in the 2030’s and 2050’s to represent the change in the system. Current load values were not included as the purpose of the study was to assess vulnerabilities in the context of changes in climate parameters in the future only. (Response Validated by AECOM/RSI).

b) Please refer to Table 1.
### Table 1: Load projections and load of 2017 by Transmission Station

<table>
<thead>
<tr>
<th>Service Area</th>
<th>Number of Stations</th>
<th>Load (2017)</th>
<th>Projected Load (2030’s)</th>
<th>Projected Load (2050’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Former Toronto</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Downtown Core (115KV/13.8KV)</strong></td>
<td>1</td>
<td>&lt;70%</td>
<td>86-95%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>70-85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>86-95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Downtown outer (115/13.8,230/115KV,115/27.6KV)</strong></td>
<td>2</td>
<td>&lt;70%</td>
<td>70-85%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>86-95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>70-85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>86-95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>86-95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Horseshoe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>North Stations (230/27.6 KV)</strong></td>
<td>1</td>
<td>&lt;70%</td>
<td>86-95%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>70-85%</td>
<td></td>
<td>&gt;100%</td>
</tr>
<tr>
<td><strong>East (230/27.6KV,230/115KV)</strong></td>
<td>1</td>
<td>&lt;70%</td>
<td>86-95%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>&lt;70%</td>
<td>70-85%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>70-85%</td>
<td>86-95%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>86-95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>70-85%</td>
<td>&gt;100%</td>
<td></td>
</tr>
<tr>
<td><strong>Northwest (230KV/27.6KV)</strong></td>
<td>1</td>
<td>&lt;70%</td>
<td>86-95%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>&lt;70%</td>
<td>70-85%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>70-85%</td>
<td>86-95%</td>
<td>&gt;100%</td>
</tr>
<tr>
<td><strong>Southwest (230/27.6,230/115 KV)</strong></td>
<td>2</td>
<td>70-85%</td>
<td>86-95%</td>
<td>&gt;100%</td>
</tr>
</tbody>
</table>

Note 1: The addition of 2017 necessitated formatting changes to the table, specifically under the “Number of Stations” column.

**RESPONSE (PREPARED BY AECOM/RSI):**

c) The 2030’s and 2050’s represent the beginning of each decade for infrastructure capacity considerations (i.e., load forecasts for Toronto Hydro infrastructure), and represent 30-year averaging periods centered on each decade (e.g. the “2030’s”
represent projected climate averages for the period 2020 to 2049) for the climate parameter calculations. Please see response to part (a).

The climate assessment examines the probability of climate parameters occurring, expressed both as a study period probability value (i.e. what is the probability of a climate parameter occurring sometime between 2015 – 2050) and an annual probability value centred around the 2030's and 2050's (i.e. what is the annual probability of a climate parameter occurring around the 2030's and 2050's). The projected loads were therefore estimated for around the 2030's and 2050's, to be considered alongside the climate data. Since these are projections only, they are intended to represent average future conditions rather than a specific year.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 41:

Reference(s): Exhibit 2B, Section D, Appendix D, p. 20

Preamble:

“Individual GCMs contain inherent biases when attempting to recreate historical climate, for example being either too cool or warm compared to historical averages. To compensate for this effect, the “Delta-method” was employed. First, GCMs were evaluated to determine changes from their own respective baselines. This difference between model baseline and projected conditions is then applied to the observed historical climate baseline. For example, if the GCM ensemble indicated an average increase of 2 degrees between the baseline period and the 2050’s, and a given station shows an average annual temperature of 3°C, then the projected annual average temperature for that location for the 2050’s becomes 5°C. This represents the “delta”, or the change in climate parameter based on the difference projected by the GCM ensemble applied to historical baseline data.”

To demonstrate the accuracy of the method please recreate historical climate for Toronto for each decade from 1920 to 2010 using each one of the GCMs that the authors used in this report and compare it to actual historical averages for that decade.

RESPONSE (PREPARED BY AECOM/RSI):

This request is impossible to satisfy, since GCM historical data from the last IPCC assessment does not extend back to 1920. GCM data from the last assessment begins

Panel: Distribution System Capital and Maintenance
around 1961. Current Best Practice is to use the most recent climate normal period (in this case 1981-2010), since this represents our current climate. This is the most recent normals period provided by ECCC, for example, on their website. Climate normals change with time, therefore applying a 1960-era climate normals would effectively be applying a comparison to a “stale” range of climate normal conditions.

Furthermore, we note that re-creation of Toronto’s climate based on GCM output alone is not relevant for this study. The historical baseline, used for both calculation of historical climate statistics as well as bias adjustment for GCMs, employed real observations from climate stations and not modeled information.

Even if this requested analysis were possible, to conduct this effort for each GCM individually would likely be considered cost prohibitive for this process and would not yield usable results. Scientific research has indicated that using an ensemble model approach can historically BEST represent actual observations over a single model for a climate Normal period of record. (Taylor, K.E., R.J. Stouffer and G.A. Meehl. 2012. An overview of CMIP5 and the experiment design. Bulletin of the American Meteorological Society, 93 (4): 485-498.)
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 42:
Reference(s): Exhibit 2B, Section D, Appendix D, p. 27, Table 4-2

Please confirm that the equal to or greater than 100% load for the stations in the Horseshoe Area in 2050’s are a scenario used in computer modelling by the authors and not a forecast by Toronto Hydro.

RESPONSE:
Transmission station capacity is based on the load projection exercise completed by Toronto Hydro for this project.

For further information, please refer to Appendix F and Chapter 2, Load projections of Exhibit 2B, Section D, Appendix D. Please also refer to Exhibit 2B, Section D, Appendix D, page 27, under paragraph 2 under ‘Transmissions Stations’.
INTERROGATORY 43:

Reference(s): Exhibit 2B, Section D, Appendix D, Appendices

a) Please explain the reasons for not filing the Appendices and, in particular, the statement regarding Appendix A: “This information has been removed from the public version of this report”. Why are some parts of this report being kept away from the public?

b) Please file all missing appendices included redacted versions of confidential documents.

RESPONSE:

a) This was an oversight in filing; the information was not meant to be redacted.

b) Please see Appendix A to D to this response.

Table 1: Reconciliation between Internal and External versions of the report

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Redacted Information</th>
<th>Page on Internal</th>
<th>Page on external</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>“Appendix A – Workshop Presentations”</td>
<td>5-72</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>“Appendix F – Load Projection Methodology – Toronto Hydro”</td>
<td>161-167</td>
<td>92</td>
</tr>
<tr>
<td>C</td>
<td>“Worksheet Step 1 – Project Definition Infrastructure characteristics”</td>
<td>189-211</td>
<td>112</td>
</tr>
<tr>
<td>D</td>
<td>“Worksheet Step 2 – Data Gathering and Sufficiency”</td>
<td>212-224</td>
<td>112</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
Appendix A
Workshop Presentations
Toronto Hydro PIEVC Climate Change Risk Assessment, Phase 2
Severity Scoring Workshop

Chee F. Chan, Sophie Potvin-Champagne, AECOM
Simon Eng, Heather Auld, RSI

October 10th, 2014
## Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – 8:45</td>
<td>Introductions</td>
</tr>
<tr>
<td>8:45 – 9:30</td>
<td>Climate parameter evaluation (RSI)</td>
</tr>
<tr>
<td>9:30 – 9:45</td>
<td>Infrastructure overview (AECOM)</td>
</tr>
<tr>
<td>9:45 – 10:15</td>
<td>How we rated severity, risk (AECOM)</td>
</tr>
<tr>
<td>10:15 – 10:30</td>
<td><strong>Break</strong> (Coffee and Muffins Provided)</td>
</tr>
<tr>
<td>10:30 – 12:00</td>
<td>Workshop validation for severity ratings</td>
</tr>
<tr>
<td>12:00 – 12:45</td>
<td><strong>Lunch</strong> (Provided)</td>
</tr>
<tr>
<td>12:45 – 14:30</td>
<td>Workshop validation for severity ratings cont.</td>
</tr>
<tr>
<td>14:30 – 14:45</td>
<td><strong>Break</strong></td>
</tr>
<tr>
<td>14:45 – 15:45</td>
<td>Brainstorm potential adaptation solutions</td>
</tr>
<tr>
<td>15:45 – 16:00</td>
<td><strong>Wrap-up</strong></td>
</tr>
</tbody>
</table>
Objectives of this Workshop

• To allow RSI to present climate parameters and vet results with TH

• To allow AECOM to validate severity ratings for entire system with TH

• To identify areas requiring further investigation for severity ratings or climate probability scoring

• To identify initial adaptation solutions which should be considered
Sources of Information

REPORTS/DOCUMENTATION

• Toronto Hydro Electric System Limited, Conditions of Service, May 1, 2014

• Toronto Hydro Electric System Limited and Hydro One Networks ID #541450, Transmission connection Agreement – Schedule A, December 17, 2010

• Toronto Hydro Electric System Limited, Station Load Forecast (2014-2023), May 8th, 2014

• Toronto Hydro Electric System Limited, Manufacturer List, Excel file, 2014

• Toronto Hydro Electric System Limited, Poles List, Excel file, 2014

• Toronto Hydro Electric System Limited, Distribution System Planning Guidelines, Nov 28th, 2007

PRESENTATIONS

• THESL Presentation: Overview of Toronto Area Transmission System, May 26th, 2014

• THESL Presentation: Overview of Toronto Area Distribution System, May 26th, 2014

• AECOM Presentation: Toronto Hydro PIEVC Climate Change Risk Assessment, Phase 2, July 3rd, 2014

• A list of questions was sent to THESL after this presentation and answers were sent back, given more information of the system, from July to September 2014.

MAPS

• Toronto Hydro Electric System Limited, Feeder density map, pdf. File

• Toronto Hydro Electric System Limited, Systems map, pdf. file

• Toronto Hydro Electric System Limited, Critical & Key Customers map, pdf. File

• Toronto Hydro Electric System Limited, Flood High Resolution map, pdf. file

STANDARDS

• Toronto Hydro Electric System Limited Civil and Electrical Standards

• Hydro-Québec Standards

• IEEE Standards

• IEC Standards

• CSA Standards

MANUFACTURERS

• ABB

• SIEMENS

• S&C

• Pioneer

• Federal Pacific

• Others
System Breakdown

1- Transmission Stations
   - Transformer Stations
   - Municipal Stations
     - Toronto Hydro to Toronto Hydro
     - Toronto Hydro to Private Owner Ship
     - Transmission step-down to distribution (HO-TH)

2- Feeder Configuration
   - Underground
   - Overhead
   - Open Loop
   - Closed Loop
   - Dual Radial
   - Network
   - Radial
   - Open Loop
   - Residential (URD)
   - Compact Loop (CLD)

3- System Communications
   - Protection and Control
   - SCADA

4- Civil Structures
   - Vaults
   - Cable chambers

5 - Mechanical Auxiliary
   - Ventilation
   - Pumps
   - Sumps
Transmission Station Zones
# Severity Scoring and Examples

<table>
<thead>
<tr>
<th>Score</th>
<th>Method D</th>
<th>Stations</th>
<th>Examples</th>
<th>Feeder Descriptive</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Effect</td>
<td>Negligible or N/A</td>
<td>Negligible or N/A</td>
<td>Arrester failure, overheating cables, salt deterioration of civil/electrical equipment</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Measurable</td>
<td>Very Low - Some measurable change</td>
<td>Some loss of serviceability &amp; capacity, no loss of function</td>
<td>Overheating transformer from high load</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minor</td>
<td>Low - Slight loss of serviceability</td>
<td>Station battery – lifespan shortened</td>
<td>Overheating transformer from high load</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Moderate loss of serviceability, some loss of capacity, but no loss of function</td>
<td>Station transformer heating up, but possibility of meeting demand from another station</td>
<td>Transformer and switchgear out (replace multiple equipment), cable</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Major</td>
<td>Major loss of serviceability, some loss of capacity &amp; function</td>
<td>Station transformer heating up, need to do load shedding</td>
<td>Transformer and switchgear out (replace multiple equipment)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Serious</td>
<td>More loss of capacity &amp; function</td>
<td>Station transformer heating up, need to do load shedding for longer duration</td>
<td>Transformer and Switchgear out Flooded vault that cannot be pumped</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hazardous</td>
<td>Major - Loss of Function</td>
<td>Loss of CT/VT transformer, battery assets</td>
<td>Leaning pole/downed line</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Catastrophic</td>
<td>Extreme – Loss of Asset</td>
<td>Station trans. failure</td>
<td>Downed pole, line and transformer</td>
<td></td>
</tr>
</tbody>
</table>

Page 8
Key Concepts

• Serviceability – Ability to maintain, expected lifespan
• Capacity – “bandwidth”, ability to provide design current (applies to transformers only)
• Function – loss of electricity provision
• Structure – severe damage or loss of asset
Factors which can +/- severity ratings

• Redundancy of stations/feeders
• Emergency response times and facility may +/- severity ratings
• Key clients (in terms of vulnerabilities) will +/- severity ratings, analysed using GIS mapping
• Other vulnerable clients / considerations?
• Stations – redundancy based on geographic location, because of load characteristics (presently some stations are more heavily loaded than others)

<table>
<thead>
<tr>
<th>Redundancy</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Bus load relief required in 2014-2018</td>
</tr>
<tr>
<td>Moderate</td>
<td>Bus load relief required in 2019-2023</td>
</tr>
<tr>
<td>Good</td>
<td>No bus load relief required in 2019-2023</td>
</tr>
<tr>
<td>Best</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Redundancy - Feeders

- Feeders – redundancy based on electrical configuration

<table>
<thead>
<tr>
<th>Redundancy</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Radial</td>
</tr>
<tr>
<td>Moderate</td>
<td>URD</td>
</tr>
<tr>
<td>Good</td>
<td>Dual Radial</td>
</tr>
<tr>
<td>Best</td>
<td>Network</td>
</tr>
</tbody>
</table>
Risk

- Risk is a function of $P \times S$
- PIEVC Process – a high level prioritization exercise
- Where do we need to focus future study, given climate change?

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Threshold</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 12</td>
<td>Low</td>
<td>No further consideration necessary</td>
</tr>
<tr>
<td>12 &lt; 36</td>
<td>Medium</td>
<td>Further investigation <em>may</em> be required through PIEVC engineering analysis</td>
</tr>
<tr>
<td>36 +</td>
<td>High</td>
<td>Further investigation <em>is</em> required, no further consideration necessary in this risk process</td>
</tr>
</tbody>
</table>
### High Temperature - Stations

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transmission Systems to Municipal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. Downtown core stations</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2. Downtown outer stations w/ Leaside</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3. Leaside (13.8 kV)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1. Residential (single-family)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. Residential (apartment)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3. Feeder Configuration: Underground (divided by types)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>3.1. Subtransmission (underground)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3.2. Distribution (underground)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>4. Communications (divided by type)</td>
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<tr>
<td>4.1. Voice (cable)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2. SCADA</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5. Cell Structures (divided by categories)</td>
<td></td>
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<tr>
<td>5.1. Transmission &amp; Substation Structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5.2. Equipment support</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3. Underground Feeder: Toronto</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4. Reinforced concrete vault chambers</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5. Concrete vault (single-family)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6. Underground cable ducts</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.7. Underground feeder: Toronto Area</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.8. Reinforced concrete vault chambers</td>
<td>Yes</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>5.9. Reinforced concrete vault chambers</td>
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<td></td>
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<tr>
<td>5.10. Concrete vault (single-family)</td>
<td>Yes</td>
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### Freezing Rain - Stations

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*Note: Detailed severity evaluation criteria are provided for each storm type and event.*
Validating Severity Evaluation

Wind - Stations

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[Table continues with various severity evaluations and corresponding damage scenarios]
### Validating Severity Evaluation

#### High Temperature - Stations

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<td>3.1: Dual Radial System - Underground</td>
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## Validating Severity Evaluation

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<thead>
<tr>
<th>Category</th>
<th>All - Overhead Feeders</th>
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<td><strong>Infrastructure Class or Category:</strong></td>
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### Temperature – Underground Feeders

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<td>1.1.1. Downtown core stations (13.8 kV)</td>
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<td>1.1.2. Downtown core stations (6 kV)</td>
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<td>1.1.3. Downtown core stations (3 kV)</td>
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<td>1.2. Residential</td>
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<td>1.2.2. Residential (6 kV)</td>
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<td>1.2.3. Residential (3 kV)</td>
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<tr>
<td>2. Municipal Stations (divided by geography)</td>
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<tr>
<td>2.1. Toronto Hydro to Toronto Hydro &amp; Private owner Ship</td>
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<td>2.1.1. Former Toronto (industrial)</td>
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<td>2.1.2. Former Toronto (residential)</td>
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<td>2.1.3. Former Toronto (commercial)</td>
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<td>3. Feeder Configuration: Underground (divided by types)</td>
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<td>3.1. Substation (underground)</td>
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<td>4. Communications (divided by type)</td>
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<td>4.1. SCADA &amp; control systems</td>
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<td></td>
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<td>5. Analysis &amp; Planning (underground)</td>
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<tr>
<td>5.1. Substation (underground)</td>
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<td>5.1.2. Substation (6 kV)</td>
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<tr>
<td>5.1.3. Substation (3 kV)</td>
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</table>

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**Note:** The above table provides a snapshot of the temperature evaluation for underground feeders in various categories and locations. The data includes metrics such as maximum temperature and corresponding consequences. Further analysis and planning are required for effective management and mitigation strategies.
## Validating Severity Evaluation

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<thead>
<tr>
<th>Infrastructure Class or Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>1 Transmission/hub to Municipal</td>
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<td>1.3 Hospitals</td>
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<td>2.1 Toronto Hydro to Toronto Hydro &amp; Private owner Ship</td>
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<td>3 Feeder Configuration: Underground (divided by types)</td>
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### Heavy Rainfall – Underground Feeders

- Heavy Rainfall – Underground Feeders
- Underground Feeders – Toronto
Freezing Rain – Underground feeders

Freezing Rain – Civil
### High Wind – Underground and Padmount feeders

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>High Winds 25 mph (75 km/h)</th>
<th>High Winds 60 mph (100 km/h)</th>
<th>High Winds 110 mph (175 km/h)</th>
<th>High Winds 150 mph (240 km/h)</th>
<th>High Winds 200 mph (320 km/h)</th>
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<td>Padmount</td>
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*Note: The table above details the evaluation criteria for different equipment types under various wind speeds.*
# Validating Severity Evaluation

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<tr>
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<th>Evaluation 2</th>
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<th>Evaluation 5</th>
<th>Evaluation 6</th>
<th>Evaluation 7</th>
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<td>Maximum temp above 25°C</td>
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<td>Maximum temp above 35°C</td>
<td>Maximum temp above 40°C</td>
<td>Maximum temp above 45°C</td>
<td>Maximum temp above 50°C</td>
<td>Maximum temp above 55°C</td>
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*All – Communications and Protection Systems*
Validating Severity Evaluation

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<th>Freezing Rate/Weather</th>
<th>Freeze Rate/Weather</th>
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**Lightning**

Additional details and criteria for each severity level are provided in the table.
### Validating Severity Evaluation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Ice on station equipment</td>
<td>Ice on station equipment</td>
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<tr>
<td>2. Snow accumulation</td>
<td>Snow accumulation</td>
</tr>
<tr>
<td>3. High winds</td>
<td>High winds</td>
</tr>
<tr>
<td>4. Tornadoes</td>
<td>Tornadoes</td>
</tr>
<tr>
<td>5. Lightning</td>
<td>Lightning</td>
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#### Table 2: Snow Evaluation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Impact</th>
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<tbody>
<tr>
<td>1. Ice on station equipment with snow accumulation</td>
<td>Critical</td>
</tr>
<tr>
<td>2. Snow accumulation with high winds</td>
<td>Major</td>
</tr>
<tr>
<td>3. High winds with tornadoes</td>
<td>Minor</td>
</tr>
<tr>
<td>4. Tornadoes with lightning</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

**NOTES:**
- Critical: Immediate action required.
- Major: Significant action required.
- Minor: Minimal action required.
- Minimal: No action required.
Adaptation solutions

Target areas:
• Station transformers – heat
• Distribution transformers - heat
• Overhead distribution – freezing rain
• Underground vaults - flooding
• Tornadoes – all above ground

Potential solutions:
• Emergency response preparedness of team
• Smart Grid
• Mobile generation / dispersed generation
• Microgrid planning
Thank You

sophie.potvin-champagne@aecom.com
chee.f.chan@aecom.com
Toronto Hydro PIEVC Climate Change Risk Assessment, Phase 2

Chee F. Chan, Sophie Potvin-Champagne, AECOM
Simon Eng, Heather Auld, Neil Comer, Erik Sparling, RSI

July 3rd, 2014
Meeting Agenda and Objectives

1:00 – 1:30 Background – AECOM, RSI
   ✓ Present overview of PIEVC Phase 2 Project, Climate change for Toronto Hydro in a nutshell

1:30 – 2:15 Infrastructure Characterization - AECOM
   ✓ Toronto Hydro to validate characterization

2:15 – 3:15 Climate Parameters - RSI
   ✓ Toronto Hydro to validate climate parameters and thresholds

3:15 – 4:00 Discussion Subjects
   ✓ Discuss range of subjects pertaining to characterization and severity assessment

4:00 Adjourn
Background

1:00 – 1:30
Background – PIEVC Phase 1 Study

• Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol – an engineering based climate change risk assessment methodology

• Summer 2012 – AECOM and RSI completed pilot PIEVC Risk Assessment of TH Distribution Infrastructure to current climate conditions (Pilot Study, Phase 1)
Background – PIEVC Phase 1 Study

Project used as pilot to test application of PIEVC Protocol to electrical infrastructure.

Pilot study looked at equipment within feeders (e.g. transformers, conductors, switches), but not at feeders, stations or systems.

**LOW RISK**
- Low temp, freeze-thaw, frost, snowfall, heavy rainfall, lightning strikes, drought

**MEDIUM RISK**
- High Temp, heat wave, extreme humidity, high wind/downburst, heavy rainfall, freezing rain, ice storms, lightning strikes

**HIGH RISK**
- High wind/downburst, lightning strikes

**SPECIAL CASES**
- Tornadoes, blowing snow, heavy snowfall
Background – PIEVC Phase 2 Study

• 2013: NRCan RFP → funding to complete Phase 2, TH PIEVC Climate Change Risk Assessment

• Objectives of Phase 2 TH PIEVC:
  – Conduct a climate change risk assessment of Toronto Hydro electrical distribution infrastructure for the 2030 and 2050 time horizons
  – Map risk assessment over the City of Toronto
  – Provide high level recommendations on potential adaptation solutions and next steps
Background – PIEVC Phase 2 Study

• Phase 2 Study
  • CAP- Project Lead, AECOM-Engineering, RSI-Climate
  • Project Advisory Committee – NRCan, Engineers Canada, City of Toronto, Hydro One, OPA, IESO
  • March 2014 – March 2015
  • Time horizons for study set tentatively at 2030s (2010 – 2040) and 2050s (2040 – 2060);

• Parallel work – PIEVC Transmission Project
  • Looking at Cherrywood TS + lines
  • Joint PAC, climate info, and potential outage scenarios
Background - Comparison of Phase 1 and 2 Study Areas

Approximate Pilot Case Study Areas (2012)

Current Project Study Area (2014)
Background – Phase 2 Study Objectives

1. Identify and characterize the electrical infrastructure to be studied;
   • PIEVC Step 1 and 2 – completed by summer 2014

2. Understand climate change parameters and thresholds for TH electrical distribution assets;
   • PIEVC Step 2 – completed by summer 2014

3. Assess climate change related risks;
   • PIEVC Step 3 – severity scoring September 2014, meeting
Background – Phase 2 Study Objectives

4. Develop adaptation options and document the entire risk assessment process
   – PIEVC Step 5 – develop adaptation options, **meeting**, Nov 2014 – Jan 2015
   – PIEVC Step 5 – prepare reports, Feb – Mar 2015

Phase 2 Study Deliverables
   – Climate Change Risk Assessment Report
     • Internal and external version for public diffusion
     • GIS mapping of system level risks
     • Discussion of wider applicability of study to other utilities
Technical Group Introductions

1:30 – 2:15
Background - Risk Assessment and Time Horizon

• Risk Assessment $R = P \times S$
  – $P =$ Probability of a negative event – use of thresholds to define point where a negative event is considered to have occurred.
  – $S =$ Severity of the event, given that it has happened, 2 parts:
    • Engineering severity, based on criticality to system, type of damage, operational constraints, time to replace, availability of parts, cost impacts;
    • Social severity – overlay social vulnerability indicators (e.g. low income, vulnerable building typologies, access to services, language) – under development with City of Toronto.

• Time Horizon – 2030s and 2050s
  – Phase 2 assessment does not look at legacy equipment thresholds
  – Hypothesis: 2030s, some legacy equipment will still be in the system
  – Hypothesis: 2050s, the system will be comprised of equipment built to current (post 2000) standards
Background – Scoring Engineering Severity

• Identify representative systems
  – Stations, feeders, and system communication/protection
  – Systems are divided by type and according to performance reliability
  – Representative systems contain typical sets of components

• Identify list of unique components
  – Transformers, conductors, switches, etc.

• Evaluate component vulnerability to climate parameters
  – Score engineering severity by climate parameter

• Evaluate severity score for systems
  – Identify “weakest link” – component with lowest threshold to climate parameter
  – Attenuate scoring based on system redundancies
Characterize Infrastructure Under Study
Section Outline

• **Infrastructure Characterization in 3 parts:**
  A. Choose infrastructure to be evaluated
  B. Provide general description of the infrastructure
  C. Reference additional background and detailed information sources
A. Choose the infrastructure to be evaluated – Conceptual Diagram

1-Stations
- Transmission Stations
  - Hydro-One TS
  - Transmission step-down to sub-transmission or distribution (HO-TH)
- Municipal Stations
  - Toronto Hydro to Toronto Hydro
  - Toronto Hydro to Private Owner Ship

2-Feeder Configuration
- Underground
  - Open Loop
  - Closed Loop
- Overhead
  - Rear Lot
  - Radial
  - Pilot Wire
  - Network
  - Open Loop
  - Compact Loop (CLD)

3-System Communications
- Protection and Control
- SCADA
A. Choose the infrastructure to be evaluated

Feeder Map
B. General Description of the Infrastructure

1. Stations

• Transmission Stations (TS)
  • Toronto Area total TS installed capacity = 7,496MVA, Toronto Peak: 5,082MVA
  • **Hydro-One TS (not in study scope)**
    – 500kV, 345kV, 230kV, 115kV, 69kV

• Transmission step down to sub-transmission or distribution: **Hydro-One to Toronto Hydro**
  – Horseshoe Area (20 TS) : 230kV or 115kV / 27.6kV, note: 27.6kV feeders owned by TH
  – Former Toronto (15 TS): 115kV / 13.8kV, note 13.8kV switchgears and feeders owned by TH
B. General Description of the Infrastructure
1. Stations cont.

- Municipal Stations (MS)
  - Toronto Hydro to Toronto Hydro
    - Former Toronto: Indoor Stations: 13.8kV/4 kV
    - Horseshoe Area: Outdoor Stations: 27.6 or 13.8kV/4kV

**Question:** Will the 4 kV system be phased out? When?

- Toronto Hydro to Private ownership
  - Service at LV (e.g. 600/347 V or 208/120 V) with loads from 300kVA-2500kVA: TH Equipped Vault with modular switchgear and transformer;
  - Service at 13.8kV at loads of 2500kVA to 10MVA+: TH supplies 2 or 3 feeders, and customer owns substation (pilot wire protection on 10MVA+ substations);
B. General Description of the Infrastructure
1. Stations cont.

- **Stations: Typical Equipment**
  - Power Transformers: oil-type or dry-type (indoor), types of cooling: ONAN, ONAF/OFAF/ODAF, ONWF?
  - Current and Voltage Transformers: SF6 or oil types
  - Disconnect switches
  - Interrupters (Whip Arcing Horns?) and Circuit Breakers: SF6
  - Bus Bar
  - Overhead Ground Wire
  - Arresters
  - HV/MV Switchgear: Indoor or Outdoor

**Questions:**
1. *Which types of stations does TH have? AIS (Metal-Clad or Air) and GIS (SF6 or Vacuum);*
2. *Does TH own some of the 27.6kV switchgear? Which ones? Is it indoor or outdoor?*
3. *Is the 4kV equipment located indoors for municipal stations for Horseshoe locations (considering that they are all indoor in Former Toronto)?
B. General Description of the Infrastructure
2. Feeder Configuration

• Underground
  • Open Loop
    – Dual Radial System
      » Each feeder: 50% of Load
      » Some overloads possible
      » Large commercial and industrial customers
    – Residential Distribution System (URD)
      » Up to 500kVA customer demand
      » 2 loops: Main loop and Sub-loop + branch circuit
    – Compact Loop Design (CLD)

• Closed Loop
  – Pilot Wire
    » Large Customer: 20MVA
    » Dedicated feeders
  – Network
    » Grid or Spot Network Vault
    » Compact Radial Design or Stand Alone Network Protector
B. General Description of the Infrastructure
2. Feeder Configuration – cont.

• **Underground: Typical Equipment**
  • **Dual Radial System**
    – Switchgear: Modular (90’s - present):
    – Each Vault contains:
      o 2 load-break Switch Module: Metal enclosed, submersible, air insulated
      o 1 fuse Module: Metal enclosed, submersible, air insulated
      o Vacuum Loadbreak switch + SF6 insulating gas
      o 1 Transformer: Subway, Padmount
      o Feeders/Cables
    – Pumps

• **URD system**
  – Cables: PILC (old) or TRXPLE, (Q: do you have oil-filled cables)?
  – 4- or 5-way SF6 switch (600 A, 200A): Motorized or manual: Submersible & Padmount
  – Fault Filter Electronic Fuses, 80E SF6 Power Fuses, Current Limiting Fused
  – Elbows (600A- non-load break, 200A-load break)
  – 3ph or 1ph Transformers: Submersible, Padmount
  – 2- or 3-way Vacuum Switch (Transformer room-Customer locations)
  – Faulted Circuit Indicators (Main loop: SCADA connected, sub-loop: Non-SCADA)
  – Pumps
B. General Description of the Infrastructure

2. Feeder Configuration – cont.

• **Underground: Typical Equipment**
  • **Compact Loop Design**
    – 600A SF6 Load Break Switch: submersible, stainless steel tank (Mini-Rupter?)
    – Transformers: ONAN, subway type
    – Cables: TRXLPE, XLPE
    – Faulted Circuit Indicators
    – Relays
    – Molded Current Limiting Fuses (submersible)
    – Pumps?

• **Network Distribution System**
  – Primary Feeders
  – Network Units
    o Primary Switch (3 position)
    o N/W Transformer
    o N/W Protector: Breaker, back-up fuse, Relays, CT, Cable Limiter
  – LV secondary Network grid (new installations?) or spot
  – Stand Alone Network Protector or Compact Radial Design
B. General Description of the Infrastructure
2. Feeder Configuration – cont.

• **Underground: Typical Equipment**
  • **Pilot Wire System**

  Question:
  1. What does Toronto Hydro own in these systems?
  2. What are typical pieces of equipment in this system?
B. General Description of the Infrastructure

2. Feeder Configuration – cont.

• Overhead
  • Open Loop and Radial
    – Former Toronto 4.16kV:
      o Up to 3 feeders on a pole line (most 2)
      o Tie : gang-operated switch
      o 1-3ph loads up to 300kVA
    – Former Toronto 13.8kV:
      o One standby form the same bus to supply 3-4 feeders under N-1
      o Tie only with the same station bus: SCADA switch
      o 1 feeder on a pole line
      o 1-3ph loads up to 500kVA
    – Horseshoe Area 27.6 or 13.8kV:
      o Tie with adjacent station’s feeders : Manual or SCADA switch

• Rear Lot:
  – Access more difficult (Analysis purpose)

Question: Wood and/or Concrete poles?
B. General Description of the Infrastructure

2. Feeder Configuration – cont.

• **Overhead: Typical Equipment**
  - Concrete or Cedar Poles
  - Distribution Transformers
  - Gang-operated switch, single-phase switch (?) or SCADA switch
  - Interrupters-switches
  - Conductors: Tree proof AL, AL or ACSR (CU: old)
  - Fuse disconnecting switches
  - Regulators
  - Circuit-breakers with Reclosers
  - Capacitors
B. General Description of the Infrastructure

3. System Communications

• Protection and Controls System:
  • Relays (Electromechanical and Microprocessor based)
  • Fuse, Load-break Switch, Circuit Breaker
  • Bus configurations:
    o Single Bus Single Breaker (MS: Horseshoe Area)
    o Double Bus Single Breaker (TS and MS: Most Former Toronto)
    o Double Bus Double Breaker (TS: Horseshoe Area, Some Former Toronto)
      ✓ 4 DESN
      ✓ Simple or Jones Type
      ✓ Bermondsey type
    o Double Bus and One & a Half (1-1/2 Breaker) (Former Toronto: Tearuley Station, New Copeland Station)
    o Ring Bus Configuration (TS: Esplanade station in Former Toronto)

**Question:** Does this cover all types of bus configurations?

• SCADA system
  • Switch
  • RTU
  • Fault Detector
  • Fiber optic conductor
C. Reference additional background and detailed information sources

- Overview of Toronto Area Transmission System, May 26, 2014
- Overview of Toronto Area Distribution System, May 26, 2014
- IEEE Standards
- IEC Standards
- CSA Standards
- Toronto Hydro Standards
- Hydro-Québec Standards
Climate Parameters

2:15 – 3:15
Discussion Subjects

3:15 – 4:00
Section Outline

Discussion Subjects
1. Establishing Severity Scores for System Level Analysis
2. Selecting Equipment to Aid in Severity Ratings
3. Understanding Load Characteristics
4. Understanding Restoration Procedures and Duration
5. Extending Study Results to Other Utilities Across Canada
1. Establishing Severity Scores

• Risk Score Ratings \((P \times S)\) out of 49

• Probability and Severity Scoring on 1 – 7 scale

• Severity Scoring Definitions from Pilot Study (components)

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<thead>
<tr>
<th>Score</th>
<th>Definition</th>
<th>Examples</th>
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<td>Negligible or Not Applicable</td>
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<td>Arrestor failure</td>
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<td>2</td>
<td>Low - Slight Loss of Serviceability</td>
<td>Overheating transformer</td>
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<tr>
<td>3</td>
<td>Moderate Loss of Serviceability</td>
<td>One distribution transformer out</td>
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<td>Major Loss of Serviceability - Some Loss of Capacity</td>
<td>Broken spring in underground switchgear</td>
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<td>Loss of Capacity - Some Loss of Function</td>
<td>Flooded vault that can’t be pumped</td>
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<tr>
<td>6</td>
<td>Major - Loss of Function</td>
<td>Leaning pole / Downed lines</td>
</tr>
<tr>
<td>7</td>
<td>Extreme – Loss of Asset</td>
<td>Downed pole line and transformers</td>
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</tbody>
</table>
1. Establishing Severity Scores - cont.

- Need to define scoring scale that is applicable to systems – stations, feeders and communications

- Consider:
  - Capacity – maximum output or load possible on the component
  - Function – the required role or output of a component
  - Serviceability – ability to conduct routine, planned maintenance or refurbishment activities

<table>
<thead>
<tr>
<th>Score</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Negligible or Not Applicable</td>
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<td>Very Low - Some Measurable Change</td>
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<tr>
<td>2</td>
<td>Low - Slight Loss of Serviceability</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>Moderate Loss of Serviceability</td>
<td>System functioning under compromised conditions, lifetime of certain components shortened</td>
</tr>
<tr>
<td>4</td>
<td>Major Loss of Serviceability - Some Loss of Capacity</td>
<td>?</td>
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<tr>
<td>5</td>
<td>Loss of Capacity - Some Loss of Function</td>
<td>Partial outage</td>
</tr>
<tr>
<td>6</td>
<td>Major - Loss of Function</td>
<td>Outage, some components not functioning correctly (can be repaired)</td>
</tr>
<tr>
<td>7</td>
<td>Extreme – Loss of Asset</td>
<td>Outage due to loss of many assets</td>
</tr>
</tbody>
</table>
2. Selecting Equipment to Aid in Severity Ratings

• We would like to identify specific examples of the 8 feeder classes and associated stations to help visualize weather impacts and consequences.

• In Phase 1, you identified 7 feeder examples:
  – OH-Open loop, OH-radial, (maybe rear lot)
  – UG-network (spot and grid), URD

• We would like to complete this list with examples of other feeder types.
  – Q1: Should we use these same feeders from the pilot study as representative examples?
  – Q2: Are their substations equally representative (typical, or of interest)?
2. Selecting Equipment to Aid in Severity Ratings – cont.

• These are the systems that are missing from Phase 1:
  • TS – 230 / 27.6kV, 115 / 13.8 kV
  • MS – 27.6 / 4kV, 13.8 / 4 kV
  • Feeders – UG compact loop, rear lot, UG pilot wire

• Can we obtain single line diagrams of the stations and feeders for these cases, number of clients, detailed breakdown of components (e.g. like information gathered in phase 1)?
3. Understanding Load Characteristics

• Questions:
  – What are the typical load characteristics of the different feeder and station classes?
  – Are there any particular loading patterns that make specific systems particularly vulnerable to faults?
  – What predictions can we make about future load, and load related vulnerabilities for the different feeder and station classes?
  – Follow-up with individuals?
4. Understanding Restoration Procedures and Duration

• Questions:
  – Are there specific feeder and station categories that are more problematic to restore?
  – What are the problematic parts of the system to restore (that take more time)?
  – Are there certain types of equipment that take a longer amount of time to replace if damaged (what is the stock)?
  – Do you station crews out in advance of weather events?
  – Are there any response coordination/management issues to be highlighted that may be further exacerbated by worsening weather?
  – Follow-up with individuals? Questionnaire?
5. Extending Study Results to Other Utilities

• Our initial findings indicate that equipment used by TH is standardized and also used by other electrical utilities across Canada.

**Question:** What are the factors which influence the applicability of this study to other jurisdictions?

– Altitude
– Saline environments
– Others?
Thank You

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chee.f.chan@aecom.com
Appendix F
Load Projection Methodology – Toronto Hydro
Methodology

1. Station Percentage Load are categorized as shown below:
   a. < 70% (Pale Pink)
   b. 70 – 85 % (Yellow)
   c. 86 – 95% (Orange)
   d. > 95 % (Toronto) (Red)
   e. >100 % (Horseshoe) (Red)
   f. The max station load capacity in Toronto is kept at 95% because there are no station ties among Transformer Stations in the downtown area, thus 95% load is the rule of thumb for station load relief projects.
   g. However, the horseshoe area is kept at 100% max load capacity as there are already existing station ties available.

2. The following major projects have been considered in the analysis
   a. Metrolinx Project / Eglinton RTU -> adjusted for expected load increase in 2020 & 2041
   b. Pan Am Games Toronto
   c. Data Centre near Horner TS
   d. City wide developments – proposed highrises, condos, transportation as well as population growth are NOT included in the forecast

3. 2015-2019 Station related projects have been included in the forecast, some examples are:
   a. New Buses at Horner (170 MVA) and Runnymede (120 MVA) at end of 2018 & early 2019

   **Assumptions:**
   i. Horner TS will install new feeders (16 MVA each feeder) to relief Manby TS in 2020, 2022, 2028 & 2033.
   ii. Runnymede TS will install new feeders (16 MVA each feeder) to relief Fairbank TS in 2020, 2027, 2034 & 2040.
   b. Copeland Transformer Station – In service by 2016 for first 2 buses, 2024 for next 2 buses.
   c. Any station relief projects beyond 2019 are NOT taken into account

4. Proposed Load Transfer Projects have also been included in the development of the load forecast

5. Municipal Station Conversion projects are not considered in the forecast nor the analysis

6. Station Load Transfer Assumptions
<table>
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<th>Year</th>
<th>Station at Capacity</th>
<th>Station for Relief</th>
<th>Load (MVA)</th>
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<td>Fairchild</td>
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<td>2026</td>
<td>Bridgman</td>
<td>Dufferin -&gt; Wiltshire</td>
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<td>Malvern</td>
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*Please refer to the 2014 Load Forecast and THESL TS Load Projection along with the maps for reference and clarification*
Loads Projection for Stations from 2020 to 2050
2020 Forecasted Station Load

Stations at Capacity: 0
2030 Forecasted Station Load

Stations at Capacity: 4
2040 Forecasted Station Load

Stations at Capacity: 16
2050 Forecasted Station Load

Stations at Capacity: 24
Worksheet Step 1 – Project Definition
Infrastructure characteristics
**Table of Contents**

1. General ................................................................................................................................... 2
   1.1 System Overview ............................................................................................................. 3

2. Stations ................................................................................................................................... 4
   2.1 Types ............................................................................................................................... 4
   2.2 Transformer Stations ....................................................................................................... 4
       2.2.1 Geographical Representation ................................................................................ 4
   2.3 Transmission Step Down to Distribution (Hydro One to Toronto Hydro) ............... 5
   2.4 Municipal Stations ......................................................................................................... 6
       2.4.1 Toronto Hydro to Toronto Hydro ........................................................................ 6
       2.4.2 Toronto Hydro to Private Owner Ship ............................................................... 6
   2.5 Typical Electrical Components for all Stations ............................................................ 6

3. Feeder Configuration .............................................................................................................. 8
   3.1 Underground – Open Loop .............................................................................................. 8
       3.1.1 Dual Radial System ............................................................................................. 8
       3.1.2 Underground Residential Distribution System (URD) ..................................... 9
       3.1.3 Compact Loop Design ......................................................................................... 10
   3.2 Underground – Closed Loop .......................................................................................... 11
       3.2.1 13.8 KV Network ................................................................................................. 11
   3.3 Underground- Submersible Equipment .................................................................... 12
   3.4 Underground feeders typical equipment description ............................................... 12
   3.5 Overhead ....................................................................................................................... 13

4. Communications ................................................................................................................... 19
   4.1 Protection and Control Systems .................................................................................... 19
   4.2 SCADA System ............................................................................................................. 19

5. Civil Structures ...................................................................................................................... 19

6. Auxiliary Mechanical .......................................................................................................... 21

7. Bibliography .......................................................................................................................... 22
1 General

Toronto Area transmission stations installed capacity is 7 496 MVA. The peak load of the area has been 5 082 MVA.

The Toronto Hydro receives its electricity supply from three sources:

- Leaside Transformer Station from the east with a served load of 1300 MW,
- Manby Transformer Station from the west with a served load of 700 MW,
- Portland natural gas-fired power plant on the Toronto waterfront with a served load of 550 MW.

Toronto Hydro distributes electrical power through 4.16 kV, 13.8 kV and 27.6 kV primary distribution systems. On the 27.6 kV all feeders are arranged to run in open-loop fashion with open point between adjacent feeders. At 13.8 kV, there are four types of distribution design systems:

- 13.8 kV underground radial
- 13.8 kV overhead open loop
- 13.8 kV underground open loop
- 13.8 kV underground network

The next two figures show the system levels breakdown and the border between the Former Toronto area in green and the horseshoe area in blue.

---

1 Note: According to the Ontario Power Authority (OPA), a loss of the Leaside supply path (e.g., ice storm, wind storm, fire or flood at the Leaside Transformer Station) would lead to “about 300 MW of load that would be unsupplied and rotating outages for this load would be required.”
1.1 System Overview

Major Systems Categories

1. Transmission Stations
   - Transformer Stations
   - Municipal Stations
   - Toronto Hydro to Toronto Hydro
   - Toronto Hydro to Private Owner Ship

2. Feeder Configuration
   - Underground Open Loop
   - Overhead Radial
   - Closed Loop Network
   - Residential (URD)
   - Compact Loop (CLD)

3. System Communications
   - Protection and Control
   - SCADA

4. Civil Structures
   - Vault
   - Cable chambers
   - Structures support (Overhead and stations)

5. Mechanical Auxiliary
   - Drainage System
   - Ventilation

6. Human Resources
2 Stations

2.1 Types

- Transformer Stations:
  - Transmission step-down to distribution: Link between Hydro One and Toronto Hydro: 230 kV or 115 kV to 27.6 kV or 13.8 kV
- Municipal Stations
  - Toronto to Hydro: 27.6 kV or 13.8 kV to 4 kV system
  - Toronto Hydro to Private Owner Ship

The stations are air insulated (metal-clad and air). By 2015, one 100 MVA GIS station with SF6 will be installed (Copeland).

2.2 Transformer Stations

2.2.1 Geographical Representation

- 35 transformer stations divided in the following areas:

<table>
<thead>
<tr>
<th>Service Area (Voltage step down)</th>
<th>Stations (# of stations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtown (Former Toronto)</td>
<td></td>
</tr>
<tr>
<td>Downtown core (115 kV/13.8 kV)</td>
<td>Cecil, Charles, Esplanade, Strachan, Terauley and Windsor (6) Future TS: Copeland</td>
</tr>
<tr>
<td>Downtown outer (115/13.8 kV, Leaside 230/115 kV, Runnymede 115/27.6 kV)</td>
<td>Fairbank, Runnymede (2) Basin, Bridgman, Gerrard, Glengrove, Carlaw, Wiltshire (6) Dufferin, Duplex, Leaside (13.8KV), Main (3)</td>
</tr>
<tr>
<td>Horseshoe</td>
<td></td>
</tr>
<tr>
<td>Bathurst – Finch (230/27.6 kV)</td>
<td>Bathurst, Finch</td>
</tr>
<tr>
<td>East (230 kV/27.6 kV, Leaside 230/115 kV)</td>
<td>Bermondsey, Agincourt, Malvern (2) Ellesmere, Scarborough, Warden (3) Cavanagh, Leslie (27.6 kV and 13.8 kV) (2) Sheppard, Leaside (27.6KV)</td>
</tr>
<tr>
<td>Northwest (230 kV/27.6 kV)</td>
<td>Rexdale and Woodbridge (2) Fairchild, Richview</td>
</tr>
<tr>
<td>Southwest (230/27.6 kV, Manby 230/115 kV)</td>
<td>Horner and Manby (2)</td>
</tr>
</tbody>
</table>

2 Stations were grouped in the same area only if they share similar growth patterns and load transfer along the stations is feasible.
2.3 Transmission Step Down to Distribution (Hydro One to Toronto Hydro)

- 230 kV or 115 kV circuits to 27.6 kV (Horseshoe) or 13.8 kV (Former Toronto and Horseshoe)
- **Horseshoe Area**
  - 20 sub-stations: 18: 230 kV/27.6 kV and 2: 230kV/115 kV/27.6 kV/13.8 kV (Leaside, Manby)
  - Supply:
    - Large customer owned 27.6 kV substations
    - Three-phase and single-phase loads via municipal stations
  - Max feeders: 12 at 27.6 kV (average 300-350 amps load/feeder)
  - 4-125MVA dual winding power transformers
- **Former Toronto Area**
  - 15 sub-stations: 115 kV/13.8 kV
  - Supply:
    - Large customer owned 13.8 kV substations
    - Three-phase and single-phase loads via municipal stations
  - Max feeders: 15 at 13.8 kV (average 200 amps load/feeder)
  - 4-100MVA dual winding power transformers
- **Demarcation point with Hydro One**
  - **Cavanagh 230/27.6 kV**: Almost totally owned by THESL
  - Other stations: Toronto Hydro owns the following equipment

<table>
<thead>
<tr>
<th>Stations</th>
<th>THESL equipment (in general)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin, Bridgeman, Carlaw, Cecil, Charles, Dufferin, Duplex, Esplanade, Main</td>
<td>AC &amp; DC Station service + most Station service transformers + some 13.8 kV bus + some 13.8 kV VT’s + all 13.8 kV feeders + some protection (feeder, bus protection mainly) + RTU + some telecommunications + sometimes Revenue Metering</td>
</tr>
<tr>
<td>Gerrard</td>
<td>Like above + 13.8 kV grounding transformer</td>
</tr>
<tr>
<td>Glengrove, Terauley</td>
<td>Like Gerrard + all bus breakers except bank breakers</td>
</tr>
<tr>
<td>Strachan, Wiltshire</td>
<td>Like Gerrard+ feeder breakers and bus tie breakers</td>
</tr>
<tr>
<td>Fairbank</td>
<td>All exist 13.8 kV feeders (overhead + underground) + RTU +some telecommunications</td>
</tr>
<tr>
<td>John/Windsor</td>
<td>Like Basin + 13.8 kV feeder breakers</td>
</tr>
<tr>
<td>Agincourt, Ellesmere, Horner, Leaside, Malvern, Manby, Rexdale, Richview, Runnymede, Scarborough, Sheppard, Warden,</td>
<td>27.6 kV Feeders + most RTU + some telecommunication + sometimes Revenue Meters</td>
</tr>
<tr>
<td>Bathurst, Bermondsey, Fairchild, Finch</td>
<td>All 27.6 kV feeder Breakers + all 27.6 kV breaker and feeder tie switches + all 27.6 kV feeders + all or part of 27.6 kV feeder protection + RTU + some telecommunications + sometimes revenue meters</td>
</tr>
<tr>
<td>Leslie</td>
<td>27.6 kV feeder breakers + 13.8 kV metalclad breakers + some 27.6 kV switches + some 13.8 kV VT’s + all 13.7 kV metalclad feeders + all 27.6 kV feeders + 13.7 and 27.6 feeder protection + RTU + some telecommunications</td>
</tr>
</tbody>
</table>
- Two transformer windings connected to each bus (both energized and loaded at 50%)
- All switchgear: Outdoor
  - Former Toronto
    - Two transformer windings connected to each bus (one energized, one stand-by)
    - Bus tie open
    - THESL’s switchgear (including circuit breakers): Indoor (90%) – Honi switchgear (primary): outdoor

- **Difference between the 27.6 kV system and the 13.8 kV system**
  - In the 27.6 kV system, there generally is some degree of load transfer capability between feeders supplied by different busses, and it is common to temporarily transfer load between busses through switching
  - In the 13.8 kV system, there is very limited load transfer capability between feeders originating at different busses and bus boundaries remain fixed unless permanent load transfers are planned

### 2.4 Municipal Stations

There are around 172 municipal stations. 82 are indoor stations, 40 are outdoor stations and 50 are unknown, but most likely to be partially outdoors.

#### 2.4.1 Toronto Hydro to Toronto Hydro

- Former Toronto: 13.8 kV / 4.16 kV
  - 5MVA Transformer
  - Three feeders, 400A
- Horseshoe Area: 27.6 or 13.8 kV / 13.8 or 4.16 kV
  - 10MVA Transformer
  - Six feeders, 400A

- The 4 kV system will be phased out in the core by 2030s, while approximately 50% of equipment will remain in the horseshoe area. By 2050s, it is estimated that approximately 70% of 4 kV systems will be removed from the horseshoe, given current rate of replacement.

#### 2.4.2 Toronto Hydro to Private Owner Ship

- Service at low voltage, 50 kW-999 kW, requiring transformation facilities on private property (non-residential): THESL supplies the electrical equipment and the Customer provides the transformer vault or pad. Sometimes Customer owned substation.
- Service at primary voltage, above 1 MVA (non-residential): Toronto Hydro owns the equipment
- ~2000 Customers own their equipment, 7500 customer-owned locations with 5300 contain Toronto Hydro-owned equipment.

### 2.5 Typical Electrical Components for all Stations

While each of the 35 transmission stations have site specific characteristics, representative and typical equipment found in all stations are:

- **Power transformers**: Each transmission station has large power transformers to step-down high voltage currents to distribution level voltages. Most of the power transformers in the system use oil for insulation and cooling. These large transformers have external radiators through which the oil circulates by natural convection. This type of system is called an Oil Natural Air Natural (ONAN) system. Because heat limits the capacity of power transformers,
large power transformers often also employ fans to cool down the transformer and increase its capacity under high demand. A power transformer with this cooling system is called an Oil Natural Air Forced (ONAF) system. Even though there are other types of cooling systems used in transmission stations, for example Oil Forced Air Forced (OFAF), the majority of power transformers within the study area used ONAN and ONAF systems. Furthermore OFAF systems are less sensitive to heat because the cooling mechanism is more effective.

- Lightning arresters: In case of an extremely high surge that can damage the electrical equipment, arresters are used to protect the equipment by grounding the surge current. They have a very high resistance at normal voltage and very low current drifts into the arresters. However, they have a very low resistance at extreme voltage so that the arresters act as a short-circuit for the current at the moment of a surge. Lightning arresters are located at the entry lines of transmission stations and also very close to station power transformers, as they are the most expensive pieces of equipment in the station.

- Current and voltage transformers (instrument transformers): Instrument transformers step-down at very low current and voltage the actual current and voltage passing through power lines in order to obtain a precise reading of these data. The information is sent to relays which control and protect the electrical equipment from power system faults and other abnormal conditions. Other current and voltage transformers are used for metering. The insulation medium is either sulfur hexafluoride (SF6) or oil.

- Disconnect-switches or interrupters (loadbreak switches): Switches and interrupters are used to open the lines for maintenance or repair of equipment. Interrupters can be operated under charge, and uses a medium to extinguish the arc that is created by electricity, while disconnect-switches can only be operated when the power is out and very small current is crossing the station.

- Circuit Breakers: They are used to interrupt the current in case of a fault on downstream power lines. They use a medium such as sulfur hexafluoride (SF6) to interrupt the current. Other types of circuit breakers that are found in stations include air blast (compressed air systems), air magnetic, oil and vacuum systems.

- Medium voltage switchgears: Disconnect switches, circuit breakers, cables, buses at 13.8 kV and 27.6 kV are usually metal enclosed and/or located inside. This equipment is usually owned by Toronto Hydro.

- Bus bars: Inside transmission stations, bus bars are used to conduct the current from one piece of equipment to another. The bus bars in stations are usually made of aluminium. For most of the transmission stations, the medium voltage bus bars are located indoors. The reliability of bus bars will depend of the transmission station’s configuration.

- Transmission station configurations: Transmission stations within the study area have different configurations that allow for continuous electrical supply during maintenance. Bus bars and circuit breakers may be doubled (redundant). In the horseshoe area, all transmission stations have a double bus - double breaker configuration. In the Former Toronto area, the three most common station configuration types are: double bus - single breaker, double bus - double breaker or double bus and one and a half breakers. The configurations of the transmission stations help define the redundancy and reliability of the stations.

In general, the configuration of the horseshoe area stations make them more reliable and flexible than the stations in the Former Toronto area because of the use of double bus - double breaker configurations. This configuration allows any feeder to be supplied form either bus or circuit breaker, and any bus and breaker can be taken out of service for maintenance without interrupting supply. The other configurations located in the Former Toronto area have less flexibility in this respect.

**Bus Arrangements:**
o Single Bus Single Breaker (MS: Horseshoe Area)
o Double Bus Single Breaker (TS and MS: Most Former Toronto)
o Double Bus Double Breaker (TS: Horseshoe Area, Some Former Toronto)
  ✓ 4 DESN
  ✓ Simple or Jones Type
  ✓ Bermondsey type
o Double Bus and One & a Half (1-1/2 Breaker) (Former Toronto : Terauley Station, New Copeland Station)
o Ring Bus Configuration (TS: Esplanade station in Former Toronto)

3 Feeder Configuration

3.1 Underground – Open Loop

3.1.1 Dual Radial System

General
• Supply large commercial and industrial customers, 4.16 kV stations and TTC stations 13.8 kV AC to 600 V DC
• Two feeders : Normal/Standby configuration
• Each feeder: 50% of Load
• 4-15 customers (average of 7)
• Radial System: Transformer connected via primary cables
• For large and sensitive customer: Pilot wire system (mostly downtown but few in horseshoe)
• Small shallow single phase sub vaults and big deep vaults
• 5 993 pad-mounted transformers (35 years), 873 pad-mounted switches (30 years), 1300 km of PILC (75 years), 727 km of XLPE (25 years direct buried, 40 years in concrete duct)

The customers supplied by the dual radial systems are fed by two radial feeders (one normal/one stand-by). Therefore, in case of a fault on one feeder, the other feeder can take the entire load. Customers with loads in excess of 10 MVA are supplied with three or more dedicated feeders with pilot-wire protection. This confers a higher level of redundancy to customers on dual radial systems. Distribution transformer stations are connected to both feeders with disconnect switches (one normally closed, the other normally open).

Typical electrical equipment
• Switchgear: Modular
• Each Vault contains:
  o 2 load-break Switch Module : Metal enclosed, air insulated
  o 1 fuse Module: Metal enclosed, air insulated
  o Vacuum Loadbreak switch + SF6 insulating gas
  o 1 Transformer: Vault, Subway, Padmount (metal-clad enclosure)
    Oil type (most) dry type (in above grade vaults)
  o Feeders/Cables : TRXPLE, PILC (in downtown core of Toronto) many old (95 % reached expected lives)
### 3.1.2 Underground Residential Distribution System (URD)

**General**
- Up to 500 kVA customer demand
- 2 loops: Main loop and Sub-loop + branch circuit
- 13.8kV URD feeder: Cable connected to the main bus
- Stand-by feeders backs up 8 normal feeder
- Load interrupting switch
- Transformer connected via sub-loops or branch circuits
- Big deep vaults

Feeders in the residential system are connected on a main open loop with adjacent sub-loops and branch circuits. Distribution transformers stations are connected to the sub-loops or the branch circuit. Typically, there is one stand-by feeder for up to 8 normal feeders (Toronto Hydro 2007). Radial distribution systems (branch circuits) are the most common configuration. However, it is the least reliable as customers are supplied from one single feeder. The loss of feeder results in loss of loss of multiple customers.

**Typical electrical equipment**
- Cables: TRXPLE, PILC (in downtown core of Toronto)
- 4- or 5-way SF6 switch (600 A, 200A): Motorized or manual: Submersible & Padmount (metal-clad enclosure)
- Fault Filter Electronic Fuses, 80E SF6 Power Fuses, Current Limiting Fused
- Elbows (600A- non-load break, 200A-load break)
- 3ph or 1ph Transformers: Vault, Submersible, Padmount (metal-clad enclosure)
  Oil type (most) dry type (in above grade vaults)
- 2- or 3-way Vacuum Switch (Transformer room-Customer locations)
• Faulted Circuit Indicators (Main loop: SCADA connected, sub-loop: Non-SCADA)

13.8 kV URD System

![13.8 kV URD System Diagram](image)

Figure source: (Toronto Hydro-Electric System Limited 2014)

### 3.1.3 Compact Loop Design

The compact loop is similar in design to the dual radial system but uses smaller equipment where space is limited. Its compactness allows for the equipment to be installed in existing vaults measuring 21’x7.5’x10’. The compact radial design is being used to replace existing network systems that are not heavily loaded. (Toronto Hydro 2007).

**Typical electrical equipment**
- 600A SF6 Load Break Switch: stainless steel tank
- Transformers: ONAN, subway type
- Cables: TRXLPE, XLPE
- Faulted Circuit Indicators
- Molded Current Limiting Fuses (submersible)
3.2 Underground – Closed Loop

3.2.1 13.8 KV Network

General
- Secondary Network Distribution System (Former Toronto)
- Interconnected secondaries
- 45 Networks units: 22 Major and 23 Mini-Grid
- Units in vaults: Transformers + Grounding and disconnecting switch + Protection
- First contingency condition N-1
- Big deep vaults

In the 13.8 kV network, customer loads are served by multiple feeders, transformers, network protectors. The secondaries are connected together for greater reliability and redundancy. The network system is the most reliable distribution system in Toronto (Toronto Hydro-Electric System Limited 2011), There are around 45 network units in the City of Toronto. 22 of them have major interconnections and 23 are smaller mini-grids. They are located in big deep vaults. The 13.8 kV network is principally located in downtown core and the Yonge Street and Bloor Street corridors, where the load density is very high.

Different types of network systems do exist within the Toronto Hydro system (network grid vault, spot network vault, spot automatic transfer switch-ATS, spot reverse power breaker-RPB). However, this study considers the network grid as the main network system as it is the most common type of network\(^3\). Furthermore, the vulnerability to climate events of these different network types are not expected to differ, and thus can be treated as one type.

Typical electrical equipment
- Primary Feeders
- Network Units
  - Primary Switch (3 position) – Embedded in transformer
  - N/W Transformer (dry type)
  - N/W Protector: Breaker, back-up fuse, Relays, CT, Cable Limiter
- LV secondary Network grid or spot
- Stand Alone Network Protector or Compact Radial Design

\(^3\) ATS and RPB type networks are no longer being added to the system, while spot networks are more expensive (due to the use of more network protectors, specialized switchgear and duplication of transformer capacity) and less commonly employed.
3.3 Underground- Submersible Equipment

Note: Underground Equipment: Equipment might be submersible or not:

<table>
<thead>
<tr>
<th></th>
<th>Submersible Yes/No (for new purchase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch Module</td>
<td></td>
</tr>
<tr>
<td>- SF6</td>
<td>Yes</td>
</tr>
<tr>
<td>- Vacuum</td>
<td></td>
</tr>
<tr>
<td>Fuse Module</td>
<td>Encapsulated Fuse - Yes, Fuse Cabinets - No</td>
</tr>
<tr>
<td>3ph or 1ph Transformer in vaults</td>
<td>Vault Type No, Submersible Transformer - Yes</td>
</tr>
<tr>
<td>Elbow</td>
<td>Yes</td>
</tr>
<tr>
<td>Faulted Circuit Indicators</td>
<td></td>
</tr>
<tr>
<td>Network transformer</td>
<td>Yes</td>
</tr>
<tr>
<td>Network switch</td>
<td>Embedded in Transformer - Yes</td>
</tr>
<tr>
<td>Network protectors : breaker, fuses, etc.</td>
<td>Newest One Yes, Old - No</td>
</tr>
<tr>
<td>Cable</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.4 Underground feeders typical equipment description

- Cables: The cables used in underground systems are generally insulated with cross-linked polyethylene (XLPE) or a paper insulated lead cover (PILC). The PILC cables also contain oil. Around 1300 km of PILC cables and 730 km of XLPE cables are found all over the City of Toronto. Most of the PILC cables are located in downtown Toronto and run at voltages of 13.8 kV or 4.16 kV. 95% of the PILC cables in the downtown are currently reaching their expected life span (Toronto Hydro - OM&A 2014). Cables can be directly buried (for XLPE cables) or put in concrete ducts (XLPE and PILC cables).

- Pilot wire: For large and sensitive customers, a dedicated pilot wire can be added to the cables. The dedicated pilot wire acts as a dedicated communication cable between relays and sends information quickly when abnormal conditions (e.g. fault on a power line conductor) come about. Pilot wire systems provide customers with a fault protection system.
that is more reliable. The pilot wires are mainly found in downtown with some in the horseshoe area.

- Fault circuit indicators: This equipment helps localize faults in the feeder. During the data collection phase of this study, it was noted that fault circuit indicators, even new ones, do not always work properly.

- Power transformers modules:
  - Load-break switch modules: Metal enclosed, air insulated, Vacuum or SF6 arc extinction, motorized or manual;
  - Fuse modules: Metal enclosed, air insulated, electronic fuses or SF6 power fuses or current limiting fused;
  - Power transformer: Oil type (most), dry type (in above grade vaults) or some used FR3 fluid (environmental friendly);
  - Elbows: cable connections to power transformers.

### 3.5 Overhead

**General**

- Overhead Cable from main bus
- Underground dip to overhead: three-phase ganged load-break switch
- Main feeder: Open loop
  - One back-up feed N-1
  - Load interrupting switch
  - Transformer connected via incoming and outgoing cables
  - Interruption when feeder is switch
- Secondary feeder: Radial configuration
  - Transformer connected via primary cables
  - Interruption when feeder is switch
  - Loads up to 500kVA
- Former Toronto 4.16kV:
  - Up to 3 feeders on a pole line (most 2)
  - Tie: gang-operated switch
  - 1-3ph loads up to 300kVA
- Former Toronto 13.8kV:
  - One standby form the same bus to supply 3-4 feeders under N-1
  - Tie only with the same station bus: SCADA switch
  - 1 feeder on a pole line
  - 1-3ph loads up to 500kVA
- Horseshoe Area 27.6 or 13.8kV:
  - Tie with adjacent station’s feeders: Manual or SCADA switch

Overhead power lines can carry three voltages, 27.6 kV, 13.8, and 4.16 kV (legacy), although recall the latter are being phased out. Overhead power lines can be located on the front side of a property (front-lot) or at the back of the property (rear lot). However, overhead power lines located on the rear lot of properties are progressively being replaced by front lot overhead or underground infrastructure, which provides Toronto Hydro work crews with more convenient access. Rear lot power lines will be phased out by 2030. They are not considered within the scope of this study.

The 4.16 kV power lines can accommodate up to 3 feeders on a single pole, but most of them have 2. They are tied together with gang-operated switches. In
Former Toronto area, most of the residential load is supplied from the 4.16 kV system, while only some residential areas in horseshoe area are supplied by the 4.16 kV system. Due to the phase out of the 4.16 kV system, new customers are connected to 13.8 kV circuits in the Former Toronto area and to the 27.6 kV circuits in the horseshoe area.

Typical electrical equipment

- Poles (175 416):
  - Concrete : 36%
  - Aluminum: 2%
  - Steel: 4%
  - Cedar Poles : 58%
  - Fiber glass: Negligible
  - Iron: Negligible
- Distribution Transformers: ONAN (Oil Natural Air Natural) system, always connected with a primary fuse and surge arrester;
- Gang-operated switch (~1300), single-phase switch (~300) or SCADA switch (~800, see SCADA section)
- Interrupters-switches
- Conductors: Tree proof AL, AL or ACSR (CU:old)
- Fuse disconnecting switches
- Regulators: they maintain a constant voltage level on power lines;
- Circuit-breakers with reclosers: recloser can automatically close circuit-breakers which open momentarily due to an instantaneous fault;
- Capacitors
- Porcelain & polymer Insulators

The next figure shows the distribution of feeder types across the city. The 13.8 kV network, represented in dark green, is mostly concentrated in downtown Toronto (downtown core and the Yonge Street and Bloor Street corridors), while the other feeder types (overhead, underground, loop and radial systems) can be found across the city. Figure 2 shows the density of feeders in the City of Toronto (number of feeders within 100 m of one another). Feeder densities are greater in the Former Toronto area, although there are also pockets with a high numbers of feeders in the horseshoe area.
Figure 2  Feeder density within 100 m in the City of Toronto
Figure 3  Location of the feeders, by type in the City of Toronto
Figure 4  Critical and key customers
Figure 5  Areas subject to 1 in 100 year Riverine Flooding
4 Communications

4.1 Protection and Control Systems

Typical electrical equipment
- Relays: they are designed to make a circuit breaker trip when a fault is detected. They can be electromechanical or microprocessor based;
- Fuse, Load-break Switch, Circuit Breaker
- Auxiliary systems: batteries, cranes, fire alarm systems, air compressors, etc.
- Batteries: two types: lead-acid batteries or nickel cadmium (Ni-Cd)
  For horseshoe, all batteries are at grade. For Former Toronto, 80% are at grade and 20% are in basement. When the batteries are in need of replacement, any batteries in the basement will be relocated.
  *The batteries have a life expectancy of 25 years. But they have only lasted 10 years. Their life expectancy is affected by operating and ambient temperature (over 25°C). Note: location where the batteries are stored are not climate controlled.*

4.2 SCADA System

Typical electrical equipment
- Switch (~800 SCADA switches). The switch insulators are made of polymer, and the insulation and arc quenching medium is SF₆ gas;
- The remote terminal unit (RTU). It consists of a microprocessor-controlled electronic device that transmits data to the control room and uses information from the control room to open or close the device. The communication uses either the fibre/sonet technology for the 27.6 kV and 13.8 kV transmission stations switchgear or wireless for the 13.8 kV and 4.16 kV municipal stations. Bell telecommunications lines may still be installed in some downtown area where wireless systems are not in place.
- Fault Detector
- Fiber optic conductor
- Motorized cell interrupter

It was noted that Toronto Hydro is also experiencing problems with its SCADA control systems on main feeder loops with 600 A - SF6 switches (leakages and SCADA control non-functional) and existing fault indicators (Toronto Hydro-Electric System Limited 2014). Further evaluations of the problems with this distribution automation system are underway.

5 Civil Structures

Age of structures:
We assume that structures are generally older in Downtown area than in periphery. Older structures may resist less to climate change due to their lower material properties (grade of steel, concrete compressive strength) and design loads. On other hands, optimization of structures in the 60's, for example, may have led to less resistant structure for that period.

Types of structures:
Stations:
- Gantry Towers: This portal structure consists of vertical poles whose upper parts are connected by a cross-arm. Its support the heavy conductors coming from the last pylon of the high voltage transmission line to the high voltage side of the transmission station.
- Exit lines: The distributed power exits from transmission or municipal stations through either overhead power lines or underground power lines. In this study, the first overhead
poles are considered part of station infrastructure, due to their location either within or directly adjacent to the station. For underground exit lines, the demarcation between station and feeder systems is the fence surrounding the station. This defines the demarcation between transmission stations and feeder systems, even though exit lines may respond similarly to overhead or underground feeder systems to weather events.

- Equipment supports;
- Building: for indoor stations

Underground feeders and underground transformer stations:

- Reinforced concrete cable chambers: these chambers serve as junctions and splice points for power cables;
- Concrete vaults: Reinforced concrete structures housing electrical equipment below grade;
- Underground cable ducts

Overhead feeder systems:

- As of January 1, 2014, there were 175,416 poles in Toronto Hydro’s electrical distribution system. The types of poles by construction material is as follows:
  - Concrete: 36%;
  - Aluminum: 2%;
  - Steel: 4%;
  - Cedar Poles: 58%;
  - Fiber glass: Negligible.
  - Iron: Negligible.
- Conductors and hardware (e.g. supports, bolts, etc.);
- Concrete footings (steel + aluminium + concrete + some wood poles).

Loads:

Climate loads affecting outdoor station and overhead lines:

- Ice (on conductors increasing tension force on structures);
- Wind (on conductors increasing tension force on structures);
- Thermal (mainly on conductors).

Standard used for determining climate data for outdoor structures is CSA-C22.3 – Design criteria of overhead transmission lines.

According to CSA-C22.3, climatic data for Toronto (City Hall) are:

- Minimum temperature: -20°C
- Reference wind speed: 100 km/h
- Reference ice thickness: 23 mm

Climate loads affecting underground stations and conduits:

- Rain
- Snow (on steel cover)

Standard that can be used for determining climate data for indoor structures is National Building Code of Canada 2010 (NBCC 2010).

Excerpt of NBCC 2010, attached, shows climate data for Toronto.
6 Auxiliary Mechanical

Underground system:

1. Ventilation:
   - All vaults have passive ventilation i.e. natural ventilation through slot openings through the gates.

2. Pumps:
   Two kinds of vaults in the system:
   - Small shallow single phase sub vaults: do not contain pumps as they are naturally drained to the sewers. Petro plug is installed to prevent oil from leaking into the sewer
   - Big deep vaults for Network, URD and CRD: they have pumps installed since they are very deep and usually are deeper than the city sewers. Thus drains are installed in the wall and pumps are used to elevate the water to the drain. Few vaults do have a floor natural drain (around 10%).
     - Pumps usually work when there is a detection of water. Failure can be a result of many things i.e. age, condition, wear and tear, improper connection and condition. Winter 2013, there was a deep freeze and no quality or maintenance inquiries.

3. Sumps:
   - 1647 vaults of 14937 vaults have sump pumps (11%).
   - Where there sumps, by 2030s, will have oil sensing traps that will close if oil (equipment or pollutant source) is detected
7 Bibliography

REPORTS/DOCUMENTATION
- Toronto Hydro-Electric System Limited, Conditions of Service, May 1, 2014
- Toronto Hydro-Electric System Limited and Hydro One Networks ID #541450, Transmission connection Agreement – Schedule A, December 17, 2010
- Toronto Hydro-Electric System Limited, Station Load Forecast (2014-2023), May 8th, 2014
- Toronto Hydro-Electric System Limited, Manufacturer List, Excel file, 2014
- Toronto Hydro-Electric System Limited, Poles List, Excel file, 2014

PRESENTATION
- THESL Presentation: Overview of Toronto Area Transmission System, May 26th, 2014
- THESL Presentation: Overview of Toronto Area Distribution System, May 26th, 2014
- AECOM Presentation: Toronto Hydro PIEVC Climate Change Risk Assessment, Phase 2, July 3rd, 2014
  A list of questions was sent to THESL after this presentation and answers were sent back, given more information of the system, from July to September 2014.

MAPS
- Toronto Hydro-Electric System Limited, Feeder density map, pdf. File
- Toronto Hydro-Electric System Limited, Systems map, pdf. file
- Toronto Hydro-Electric System Limited, Critical & Key Customers map, pdf. File
- Toronto Hydro-Electric System Limited, Flood High Resolution map, pdf. file

STANDARDS
- Toronto Hydro-Electric System Limited Civil and Electrical Standards
- Hydro-Québec Standards
- IEEE Standards
- IEC Standards
- CSA Standards

MANUFACTURERS
- ABB
- SIEMENS
- S&C
- Pioneer
- Federal Pacific
- Others
Worksheet Step 2 – Data Gathering and Sufficiency

Infrastructure Components

Climate Components can be found in Chapter 3 of the Report, and in Appendix B and Appendix C
# Table of Contents

1. Introduction ................................................................................................................. 3

2. Transmission and Municipal Stations ......................................................................... 4
   2.1 Current and Voltage transformers ........................................................................ 4
   2.2 Liquid-Immersed Distribution, Power, and Regulating transformers ............... 5

3. Underground system: Dual-Radial, URD and CLD ................................................... 7
   3.1 Padmount switchgears .......................................................................................... 7
   3.2 Padmount transformers ........................................................................................ 8
   3.3 Submersible Equipment-Generalities ................................................................... 8
   3.4 Submersible three-phase transformers ................................................................ 8

4. Network system .......................................................................................................... 9
   4.1 Network three-phase transformers ....................................................................... 9

5. Overhead system ......................................................................................................... 9
   5.1 General ................................................................................................................. 9
   5.2 Distribution transformers ................................................................................... 10
   5.3 Interrupter-Switches ........................................................................................... 11
   5.4 Fuses ................................................................................................................... 11

6. Communications system ........................................................................................... 12
   6.1 Relays and Relay Systems Associated with Electric Power Apparatus ............. 12
   6.2 SCADA MATE – Switching System .................................................................. 12

7. Civil structures .......................................................................................................... 13
1 Introduction

For each of the system describes in the worksheet step 1, some thresholds were found for equipment encountered in the systems.

Information on the following equipment were gathered:

For the Transmission and Municipal Stations
Current & Voltage transformers
Oil-filled power transformers

For the Underground system: Dual-Radial, URD and CLD
Padmount Switchgears & transformers
Submersible equipment & transformers

For the Network system:
Network transformers

For the Overhead system:
General information
Distribution transformers
Interrupter-Switches
Fuses

For the Communications system:
Relays and Relay Systems Associated with Electric Power Apparatus
Scada Mate Switches

For the Civil structures:

These thresholds will help us evaluate the consequences of a climate parameter over the system and focus on the equipment that are affected by the designated climate.
2 Transmission and Municipal Stations

2.1 Current and Voltage transformers

IEC 60044-1/-2

Maximal Temp:

<table>
<thead>
<tr>
<th>Category Minimum</th>
<th>Minimum temperature °C</th>
<th>Maximum temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>−5/40</td>
<td>−5</td>
<td>40</td>
</tr>
<tr>
<td>−25/40</td>
<td>−25</td>
<td>40</td>
</tr>
<tr>
<td>−40/40</td>
<td>−40</td>
<td>40</td>
</tr>
</tbody>
</table>

NOTE – In the choice of the temperature category, storage and transportation conditions should be also considered.

The conditions of humidity are as follows:

- The average value of the relative humidity, measured during a period of 24 h, does not exceed 95 %;
- The average value of the water vapour pressure for a period of 24 h does not exceed 2.2 kPa;
- The average value of the relative humidity, for a period of one month, does not exceed 90 %;
- The average value of the water vapour pressure, for a period of one month, does not exceed 1.8 kPa.

For these conditions, condensation may occasionally occur.

NOTES

1. Condensation can be expected where sudden temperature changes occur in periods of high humidity.

2. To withstand the effects of high humidity and condensation, such as breakdown of insulation or corrosion of metallic parts, current transformers designed for such conditions should be used.

3. Condensation may be prevented by special design of the housing, by suitable ventilation and heating or by the use of dehumidifying equipment.

Other service conditions for outdoor current transformers

Other service conditions considered are:

a) Average value of the ambient air temperature, measured over a period of 24 h, does not exceed 35 °C;
b) Solar radiation up to a level of 1000 W/m² (on a clear day at noon) should be considered;
c) The ambient air may be polluted by dust, smoke, corrosive gas, vapours or salt. The pollution levels are given in table 7;
d) The wind pressure does not exceed 700 Pa (corresponding to 34 m/s wind speed);
e) Account should be taken of the presence of condensation or precipitation.

Special Service conditions:

Ambient Air Temperature

For installation in a place where the ambient temperature can be significantly outside the normal service condition range stated in 3.1.1, the preferred ranges of minimum and maximum temperature to be specified should be:

- -50°C and 40°C for very cold climates
- -5°C and 50°C for very hot climates

In certain regions with frequent occurrence of warm humid winds, sudden changes of temperature may occur, resulting in condensations even indoors.

NOTE: Under certain conditions of solar radiation, appropriate measure e.g. roofing, forced ventilation, etc. may be necessary, or derating may be used, in order not to exceed the specified temperature rises.

2.2 Liquid-Immersed Distribution, Power, and Regulating transformers

IEEE Std C57.12.00-2010

When air-cooled, the temperature of the cooling air (ambient temperature) shall not exceed 40°C, and the average temperature of the cooling air for any 24h period shall not exceed 30°C.

The top liquid temperature of the transformer (when operating) shall not be lower than -20°C. Liquid temperatures below -20°C are not considered as usual service conditions. When water-cooled, the temperature of the cooling water (ambient temperature) shall not exceed 30°C, and the average temperature of the cooling air for any 24h period shall not exceed 25°C. Minimum water temperature shall not be lower than 1°C, unless the cooling water includes antifreeze, which is suitable for -20°C operation.

Unusual temperature and altitude conditions: Transformers may be used at higher or lower ambient temperatures than those specified, but special consideration should be given to these applications. IEEE C57.91 provides information on recommended practices.
Other unusual service conditions:
Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures or gases, steam, salt spray, excessive moisture or dripping water.

Ambient temperature outside normal range.

Unusually strong magnetic fields. It should be noted that solar magnetic disturbances may result in the flow of telluric currents in transformer neutrals.

IEEE Std C57.91 – 2011

Applications of loads in excess of nameplate rating involve some degree of risk. Evolution of free gas from insulation winding and lead conductors (insulated conductors) heated by load and eddy currents may jeopardize dielectric integrity.

Operation at high temperature will cause reduced mechanical strength of both conductor and structural insulation. These effects are of major concern during periods of transient overcurrent (through-fault) when mechanical forces reach their highest levels.

Thermal expansion of conductors, insulation materials, or structural parts at high temperature may result in permanent deformations that could contribute to mechanical or dielectric failure.

When the temperature of the top oil exceeds 105 °C (65 °C over a 40 °C ambient), there is a possibility that the oil expansion will be greater than the holding capacity of the tank and also result in a pressure that causes the pressure relief device to operate and expel the oil. The loss of oil may also create problems with the oil preservation system or expose electrical parts upon cooling.

Average ambient temperatures should cover 24 h time periods. The associated maximum temperatures should not be more than 10 °C above the average temperatures for air-cooled, and 5 °C for water-cooled transformers.

Table 3 – Loading on basis of temperatures (average ambient other than 30°C and average winding rise less than limiting values) (for quick approximation) (ambient temperature range -30 °C to 50 °C)

<table>
<thead>
<tr>
<th>Type of cooling</th>
<th>% of kVA rating</th>
<th>Decrease load for each °C higher temperature</th>
<th>Increase load for each °C lower temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Cooled – ONAN</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Water-Cooled – ONWF</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Forced Air cooled – ONAN/ONAF, ONAN/ONAF/ONAF</td>
<td>1.0</td>
<td>0.75</td>
<td></td>
</tr>
</tbody>
</table>
Forced oil, -air, -water-cooled – OFAF, OFWF, ODWF, and ONAN/OFAF/OFAF

<table>
<thead>
<tr>
<th>Transformers usually operate on a load cycle that repeats every 24 h.</th>
</tr>
</thead>
</table>

*ABB MANUFACTURER*

IEEE C57.12.00-2010 standards require that the life expectancy of the transformers shall be 180,000 hours (20.55 years) under the following conditions:
- Ambient temperature: 30 °C for 24 hours
- Full load
- Hottest point: 110 °C max

The power transformers can operate normally even with an ambient temperature of 40 °C for 10 hours without affecting the expected insulation transformer life if the temperature of the hot spot does not exceed 110 °C in these conditions. For a distribution transformer fill with oil designed according to IEEE standards, it means that the average load in such a case should not exceed 80-85% of the nominal kVA nameplate.

- Ambient temperature: 40 °C for 10 hours
- 80-85 % load
- Hottest point: 110 °C max

When overloading, see ANSI C57.91, for 8°C above the insulation temperature, % of loss life is double.

### 3 Underground system: Dual-Radial, URD and CLD

#### 3.1 Padmount switchgears

IEEE Std 1 C37.73-1998

Single-phase and three-phase, dead-front and live-front, pad-mounted, load-interrupter switches with expulsion, current-liming, and other types of fuses in enclosures up to 38 kV rated maximum voltage.
- The ambient temperature is not above 40°C or below -30°C.
- Unusual service conditions: The pad-mounted fused switchgear (PMFSG) may be applied at higher or lower ambient temperatures than specified, but performance may be affected and special consideration shall be given to these applications.
- Among such unusual conditions:
  - Exposure to damaging fumes or vapors, excessive dust, explosive mixtures of dust or gases, and steam or excessive moisture
Flooding;

3.2 Padmount transformers

Pad-Mounted Compartmental-type, Self-Cooled, Three-Phase Distribution Transformers (2500 kVA and Smaller); High Voltage, 34 500 GrdY/19 920 V and below; Low Voltage, 480 V and below;

Pad-Mounted Type, Self-Cooled, Single-Phase Distribution Transformers; High Voltage, 34 500 GrdY/19 920 V and below; Low Voltage, 240/120 V; 167 kVA and Smaller
IEEE Std 1 C57.12.34 & IEEE C57.12.38-2009

- Refer to IEEE C57.12.00-2010 standard for normal conditions (see transmission and municipal stations section)

3.3 Submersible Equipment-Generalities

IEEE Std C57.12.32-2002

This standard includes:

- Submersible distribution transformers
- Submersible network transformers
- Submersible network protectors
- Submersible switchgear
- Submersible capacitors or inductors
- Submersible junction enclosures
- Submersible metering equipment

The enclosure shall be designed to shed water and minimize areas where corrosive elements can accumulate (such as in and around cooling tubes)

Test: 60°C, -23°C, 5% NaCl solution, 60°C and 85% relative humidity

3.4 Submersible three-phase transformers

IEEE Std 1 C57.12.40

3750 kVA and Smaller, High Voltage 34 500 and below, Low Voltage 600 V and Below

- Transformers conforming to this standard shall be suitable for operation at rated kilovolt-amperes (kVA) and rated voltage under the usual service conditions specified in IEEE Std C57.12.00-2006 except as specified below.
• The temperature of the cooling air (enclosure ambient temperature) shall not exceed 50°C and the average temperature of the cooling air shall not exceed 40°C for any 24-hour period.
• As the transformer enclosure may be subjected to flooding or to high water tables, the transformer shall be capable of continuous unattended operation while completely submerged under a head of 3 m (10 ft) of water over the top of the tank. Manual operation of certain accessories may require that the water level be lowered below the top of the transformer prior to operation.

4 Network system

4.1 Network three-phase transformers

IEEE Std 1 C57.12.40

2500 kVA and Smaller, High Voltage 34 500 and below, Low Voltage 600 V and Below, Subway and Vault types (Liquid Immersed)
• Full load in a 40°C average ambient temperature
• With a maximum temperature not to exceed 50 °C
• A subway-type network transformer is one that is suitable for frequent or continuous submerged operation under 3 m of water
• A vault-type network transformer is one that is suitable for occasional submerged operation under 3 m of water.
• Manual operation of certain accessories may require that the water level be lowered.

5 Overhead system

5.1 General

<table>
<thead>
<tr>
<th>Element</th>
<th>Value (notes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>400 Pa or ~25 m/s (Applied cables/conductors with radial ice cover, and support structures without ice cover)</td>
</tr>
<tr>
<td>Ice</td>
<td>12.5 mm radial ice thickness (assumes ice density 900 kg/m3)</td>
</tr>
<tr>
<td>Temperatures (ambient)</td>
<td>-20°C ambient temperature (assumed for calculating tensions)</td>
</tr>
<tr>
<td>Temperature (conductor)</td>
<td>Conductor temperatures for thermal loading/sag</td>
</tr>
<tr>
<td></td>
<td>Conductors carrying &lt;1/3 ampacity: 50°C</td>
</tr>
<tr>
<td></td>
<td>Operating &gt;1/3 ampacity: 100°C bare conductors, 80°C for</td>
</tr>
<tr>
<td></td>
<td>covered or worst case scenario from ANSI/IEEE 738</td>
</tr>
</tbody>
</table>
Loads and load combinations correspond to so-called “Heavy Loading” specified in Table 30 of the CSA standard (400 Pa/12.5 mm ice/-20°C temperatures). CSA 22.3 further cautions that loads in the standard are to be taken as guidance only, and that local conditions could be assessed to further increase these values.

“Heavy loading” and “Medium loading A” adopted from previous CSA standards (i.e. pre-1976); hence infrastructure built since that time should be representative of those climatic load types.

Further Load Modifications:

Areas using large conductors and where high winds are known to be prevalent, loading of bare conductors should also be addressed
- Minimum safety factor Grade 2 or above used for Toronto Hydro:
  - Transverse load factors for wood poles (linear analysis; Table 32 in CSA 2006, Appendix E1 in CSA 2010) -> 1.5 for Grade 2 and 2.0 for Grade 1
  - Transverse load factors for concrete poles (non-linear analysis) -> 1.2 Grade 2 and 1.5 Grade 1 construction
  - Transverse load factors for steel poles (non-linear analysis) -> 1.2 and 1.5, respectively
- Maximum sag is the larger of either thermally loaded or wind and/or ice loaded value (Clause 5.2.2)
- Wind loads are to be assumed in the direction causing the greatest stress on supports and wires (7.7.1.2 & 7.9.4)
- For short spans (<200 meters) reduction factors for winds are often used. These vary with wind speed and terrain (A.7.3)

Rated Ampacity criteria (p.10):

Amperage that causes conductor to go over 60°C over ambient temperature 40°C for bare conductor or over 40°C for 40°C ambient temperature for covered conductor for following conditions:

a) Wind 0.61 m/s
b) Emissivity 0.5
c) Full sunshine
d) Solar absorption coefficient of 0.5
e) Elevation at sea level

5.2 Distribution transformers

Transformers 500 kVA and smaller: High Voltage, 34 500 V and below; Low Voltage, 7970/13800Y V and below

IEEE Std C57.12.20-2011
• Refer to IEEE C57.12-2010 for ambient conditions (see transmission and municipal stations section)

5.3 Interrupter-Switches
IEEE Std 1242-2005

Switching devices, interrupters, and interrupter switches used indoor, outdoor, or in enclosures.
• The temperature of the cooling air (ambient temperature) does not exceed 40°C
• The ambient temperature is not less than -30°C
• The wind velocity does not exceed 36 m/s for Arcing purpose.
• Unusual conditions:
  o Excessively high or low temperature
  o Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moisture, or dripping of water

5.4 Fuses

High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

IEEE Std C37.40-2003 (R2009)

Expulsion type fuses, Current-limiting fuses, fuse disconnecting switches (also in enclosure), single-pole air switch
• Usual service conditions
  ▪ For fuses and switches rated for use at a maximum application temperature of 40 °C
    • Limits of temperature for components and materials: 70 °C to 220 °C
  ▪ For fuses and switches rated for use at a maximum application temperature above 40 °C
• Unusual conditions
  ▪ Ambient temperatures less than -30 °C
  ▪ Exposure to damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moisture, or dripping water
6 Communications system

6.1 Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std C37.90-2005

Relays and relay systems used to protect and control power apparatus. A relays system may include computer interface equipment and/or communications interface equipment, such as a carrier transmitter/receiver or audio tone equipment.

- **Operational temperature range:** Manufacturer shall select between:
  - -40°C to +70°C
  - -30°C to + 65°C
  - -20° to + 55°C
  - Range defined by the manufacturer, but must encompass -20°C to +55°C

- **Non-operational temperature range:** for transport, storage and installation
  Manufacturer shall select between:
  - -50°C to +85°C
  - -40°C to + 75°C
  - -30° to + 65°C
  - Range defined by the manufacturer, but must encompass -30°C to +65°C

- **Relays and Relay Systems withstand an average relative humidity up to 55%, with excursions up to 95 % for a maximum of 96 h, without internal condensation.**

- **Other conditions may require special construction, treatment, or operation considerations, and these shall be brought to the attention of those responsible for the application, manufacture, and operation of relays and relay systems.** Among such conditions are exposure to the following:
  - Moisture or dripping water
  - Salt air
  - Extreme temperature or sudden change in temperature

6.2 SCADA MATE – Switching System

S&C Detailed Functional Specification Guide

- The switch shall perform as intended at temperatures form -40°C to +40°C.
- Sensors shall be accurate within ±3% across the tested temperature range of -40°C to +40°C.
The communication and control unit and all standard components shall be rated for an ambient temperature range of -40°C to 70°C.
The automatic switch control and all standard components shall be rated for an ambient temperature range of -40°C to 70°C.

6.3 **Arresters**

Arresters that have counters are arresters of voltages above approximately 100 kV. So only those in the stations can have these counters for our project. The arresters are design based on a voltage rate, not on a number of flashes. The main reason use of surge counters is to check if a particular phase or transmission line suffers from an exceptionally high number of overvoltages leading to arrester operation.
The number of flashes help us for the design of overhead ground wire over the substations.

So in final, I think we can only use the 25 days/year, 3.6 flash/km²/year for the substations design (system levels: Transmission and Municipal Stations) and not really for the feeders.

7 **Civil structures**
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 44:

Reference(s): Exhibit 2B, Section D, Appendix D, Appendix B, B.3.1

Preamble:
"To establish reliable statistics on the frequency of events, long term records are preferred and with this area, there are some stations available. It is generally accepted that to establish a ‘normal’ climate, a minimum of 30 years of data as required. This supposedly ensures that short term natural variability is averaged out. Detailed hourly observations are usually only available at airport locations such as Toronto Pearson, Buttonville and Toronto Island. These airport locations are also typically the only source of variables other than temperature and precipitation (such as wind or weather observations). Of these, Toronto Pearson has the lengthiest reliable data record. Those regional stations for which normals data was calculated for 1981-2010 are shown in Figure B.2."

a) Who has “generally accepted” that 30 years of data is required to establish a “normal” climate?

b) Why would the period from 1981 to 2020 represent the normal climate for Toronto? Why exclude the warm period in the 1930’s and the cold period in the 1970’s?
RESPONSE (PREPARED BY AECOM/RSI):

a) The baseline period is set to a 30-year average, as is best practice adopted by ECCC and recommended by the World Meteorological Organisation (WMO). Please see WMO Guidelines on the Calculation of Climate Normals – 2017, WMO #1203.

b) The baseline period is set to a 30-year average of most-recent 30-year period finishing in a year ending with 0, as is best practice adopted by ECCC and recommended by the World Meteorological Organisation (WMO). Please see WMO Guidelines on the Calculation of Climate Normals – 2017, WMO #1203. A 1981–2010 averaging period is considered much more likely to be representative of conditions in 2018 than the 1951–1980 period, as noted by the WMO.

In Canada, this Best Practice is adhered to by ECCC. ECCC produces climate normals in 30-year periods in accordance with this Best Practice. The current and “official” normals period is then 1981-2010 (RSI assumes the period indicated should reflect 1981-2010, NOT 1981-2020 as written).
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 45:

Reference(s): Exhibit 2B, Section D, Appendix D, Appendix B, B.3.2.3

Preamble:

“Each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850.”

Please provide the average Toronto temperature for each decade from 1850 to 2010 and compare it to the average temperature at the Earth’s surface for the entire planet for every decade from 1850 to 2020. If the authors are unable to provide this information please explain why.

RESPONSE (PREPARED BY AECOM/RSI):

The requested analysis represents a significant undertaking. It appears that the question challenges currently accepted peer-reviewed climate science which has ‘unequivocally’ implicated human influence on our climate. Given the readily available and publicly accessible scientific literature on this issue, we do not believe that the requested analysis, which involves a significant amount of effort and resource is justified.

1 "The temperature has been increasing almost everywhere in Canada. The rate of warming in Canada is more than double the global average, with warming occurring even faster in many areas of northern Canada." (found at the following link https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/basics/trends-projections/changes-temperature.html

"These results, when compared with global temperature trends calculated over the same time period, indicate that the rate of warming in Canada as a whole has been more than double that of the global mean, and that warming in northern Canada (i.e., north of 60°N) has been roughly three times the global mean.” To access the graph, use the following link https://www.canada.ca/en/environment-climate-change/services/climate-change/publications/data-scenarios-synthesis-recent-observation/chapter-2.html

Panel: Distribution System Capital and Maintenance
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 46:

Reference(s): Exhibit 2B, Section D, Appendix D, Original, Appendix C

Preamble:

On October 15, 1954, Hurricane Hazel hit Toronto. There was widespread flooding, power outages and 35 people lost their lives.

a) Are the authors of the report aware of that storm?

b) Have they taken it into account in their analysis?

RESPONSE (PREPARED BY AECOM/RSI):

a) Yes.

b) Yes, this event was considered in the analysis, along with the July 2013 extreme rainfall amounts. Rainfall amounts for both storms are best captured by the Toronto Pearson Airport Intensity-Duration-Frequency (IDF) data for the period 1950-2013. Note that the July 2013 thunderstorm rainfall event, based on ECCC IDF data, significantly exceeded the rainfall amounts recorded in Hurricane Hazel for the 1, 2 and 6 hour durations and also exceeded the 12-hour duration rainfall amounts over the Hurricane Hazel 12-hour amounts by some 45mm. It was only the 24-hour extreme rainfall accumulations from Hurricane Hazel that slightly exceeded the 2013 24-hour storm rainfalls by 10 mm.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 47:

Reference(s): Exhibit 2B, Section E8.3.4.1, Table 6, Table 7

Preamble:

For the period 2015-2019, Toronto Hydro requested funding of $16.9 million for fleet vehicles, $11 million on heavy duty and $5.9 million on light duty vehicles. In the current plan period, Toronto Hydro plans to invest $32.8 million on heavy duty, and $8.2 million on light duty vehicles.

a) Please provide the 2020 and 2024 Vehicle distribution and age profiles for each of LDVs and HDVs.

b) Please provide the distribution/profiles of leased vs purchased vehicles in 2020 and 2024.

c) Please provide the salvage value of the fleet replacements for each of LDV and HDV 2020-2024.

d) How are the salvage values realized? How much (estimated) is

i) Applied as down payment on new vehicles;

ii) Used for lease buy out and;

iii) Used Vehicle Sales in the used vehicles market;

iv) Other?
RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 4A-EP-51(a).

b) All vehicles are owned. Toronto Hydro does not lease any vehicles.

c) Salvage values can vary based on economic conditions and market conditions at auction. Historically, salvage values have been, on average, approximately 7 percent of the original purchase price.

d) End-of-life vehicles are sold at auction. Auction revenue is returned to THESL and recorded in Gain on Disposition of Utility and Other property account.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 48:

Reference(s): Exhibit 2B, Section E8.4.5, Options Analysis/Business Case Evaluation (“BCE”), p. 24

Preamble:
Over the 2020 to 2024 period, Toronto Hydro forecasts spending $281.4 million across the three IT/OT Program segments. This represents an increase of $50.2 million, or approximately 22%, compared to 2015 to 2019 spending,

Please file the Summary of the 2020-2024 Business Plan for IT.

RESPONSE:
The 2020-2024 IT plan is detailed in the pre-filed evidence at Exhibit 2B, Section E8.4. To summarize, the plan includes investment in hardware, software, and communication assets that provide critical support to Toronto Hydro’s customer and business-facing services. The objective of the 2020-2024 plan is to provide reliable technology solutions and services to support Toronto Hydro’s business functions, including effective and reliable service to customers, safe and efficient management, and operation of the distribution system, compliance with legal and regulatory requirements, and sustainment of the utility’s long-term financial viability. The proposed costs are supported by an independent benchmarking study conducted by Gartner. This study, filed at Appendix A to the program evidence, concluded that Toronto Hydro’s total IT expenditures per user in both 2017 and 2020 benchmark competitively against industry peers.
RESPONSES TO ENERGY PROBE RESEARCH FOUNDATION

INTERROGATORIES

INTERROGATORY 49:

Reference(s): Exhibit 2B, Section E8.4 Appendix A - Gartner Report

a) Please provide a copy of the Scope provided to Gartner by TH.

b) Please Define “Budget” and relate to the TH evidence at Exhibit 2B Section E8.4 Page 14 Table 5.

“Over the 2020 to 2024 period, Toronto Hydro forecasts spending $281.4 million across the three IT/OT Program segments. This represents an increase of $50.2 million (or approximately 22 percent) compared to 2015 to 2019 spending.”

c) What is meant by “Industry” be specific e.g. are the peer group all urban distribution utilities?

d) Why is Revenue a good indicator? Please explain relative to other benchmarks.

e) Please provide the following additional Benchmarks for TH and Peer Group 25-75% Range and Average and tabulate and chart the results.

i) IT budget per Gross Assets

ii) IT budget per Customer

iii) IT Budget per Employee

f) Comment on the result, including whether TH is, or is not, a good/cost-effective IT performer
RESPONSE (PREPARED BY TORONTO HYDRO):

a) Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-8.

RESPONSE (PREPARED BY GARTNER):

b) Gartner defines IT Budget as being the best estimate of total spending at the end of the 12-month budget period for IT to support the enterprise. IT spending/budget can come from anywhere in the enterprise that incurs IT costs, and it is not limited to the IT organization. It includes estimates by enterprises on decentralized IT spending and or 'shadow' IT. It is calculated on an annualized 'cash flow view' basis, and, therefore, contains capital spending and operational expenses, but not depreciation or amortization. Gartner specifically excludes Operational Technology (OT) from its definition.

Exhibit 2B, Section E8.4, Page 14, Table 5 is in respect of Capital, not Capital plus Operational Expenses, as is stated in Gartner’s definition. There is also a note in the paragraph below the table in Exhibit 2B Section E8.4 Page 14 Table 5 stating that the costs include “three IT/OT Program segments.” Since the scope of costs between what is reported in Exhibit 2B, Section E8.4, pg. 14, Table 5 and the Gartner benchmark are different, Gartner cannot relate the benchmark results to Exhibit 2B, Section E8.4, pg. 14 Table 5.

c) Gartner defines the utilities industry as organizations from which their primary revenue stream is derived from one or more of the following: Electric Utilities, Electric Power Generation by Solar, Wind, Fossil Fuels, Nuclear, and Hydro, Electric Power Distribution, Electric Power Transmission and Control, Gas Utilities, Natural Gas Transmission, Retail Energy Marketing, Independent/Merchant Power, Water Utilities, Wastewater Treatment, Water Distribution.
For Toronto Hydro, the peer group only included organizations from the following sub-sectors: Electric Utilities, Electric Power Generation by Solar, Wind, Fossil Fuels, Nuclear, and Hydro, Electric Power Distribution, Electric Power Transmission and Control.

For the benchmark of Toronto Hydro, Gartner selected a peer group of utilities that had conducted a benchmark with Gartner within the previous 18 months, that had total annual revenue similar to Toronto Hydro and that had distribution services in urban areas.

d) IT spending as a percent of revenue is the most recognized measure of total IT investment relative to top-line business results. The value of this measure is that it assists in identifying the competitiveness of investment levels relative to the most fundamental measure of business performance: revenue. IT spending as a percent of revenue alone does not highlight why spending levels are at, above or below average (which are often misinterpreted as "good" or "bad"), nor does it reflect IT's contribution to business performance. Thus, IT spending as a percent of revenue needs to be considered in tandem with other IT intensity measures, as well as the context of business objectives, the rate of change and the overall circumstances affecting the numerator (IT spending), as well as the denominator (revenue), of the calculation.

In the benchmark for Toronto Hydro, Gartner also considered metrics for IT spending as a percentage of operational expense, IT spending per employee, revenue per employee as well as efficiency metrics for infrastructure support.
1   e)
2       i) Gartner does not have a value for “Gross Assets” from Toronto Hydro nor for the
3               members of the peer group, and so cannot calculate this metric.
4
5       ii) Gartner does not have a value for “customers” from Toronto Hydro nor for the
6               members of the peer group, and so cannot calculate this metric.
7
8       iii) 2017 IT spending per employee is on slide 21 of the Gartner report. 2017 IT
9               Spending for Toronto Hydro is equal to IT Budget, so slide 21 provides this benchmark
10              metric.
11
12   f)  On Slide 12 of the Gartner report, we state that “THESL 2017 IT infrastructure
13              spending is 13 percent ($4.7M) less than organizations of similar size would spend to
14              support the same workload, $32.4M compared to $37.1M.” This comparison is a
15              measure of cost efficiency that shows TH is a cost-efficient provider of these IT
16              services. In context with other metrics in the report including IT spending as a
17              percentage of revenue and operational expense and IT spending distributions, Gartner
18              believes Toronto Hydro is a cost-effective IT performer.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 44:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015, Table ES-1 Climate Parameters and Probability of Occurrence

What are THESL design standards including overload factor for wind and ice with overload factoring KPH and mm?

RESPONSE:
Please refer to Toronto Hydro’s response in 1B-Hann-6.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 45:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015, Table ES-1 Climate Parameters and Probability of Occurrence

What are the dates, actual wind or Ice values have exceeded the design standards including overload the from 2008-2017? [sic]

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 1B-Hann-7.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 46:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015, Table ES-1 Climate Parameters and Probability of Occurrence

What were the actual historical dates from the earliest available data to 2018 that the wind and Ice climate parameter values in Table ES-1 were reached or exceeded?

RESPONSE (PREPARED BY AECOM/RSI):

Thresholds for ice breaking points were based on studies on power outages and the comprehensive study for Public Safety Canada. These included all outages beginning from the late 1940s, with the information based on archives, climate reports, weather maps, media coverage and a database of communications tower failures for all of Southern Ontario and for US states bordering on the Northern Great Lakes.

For specific dates of significant ice storm events, please refer to the report prepared for Public Safety Canada (at the time known as the Office of Critical Infrastructure Protection and Emergency Preparedness, by Klaassen et al. (2003). In addition to the events listed

1 This report can be accessed at the following link
https://www.publicsafety.gc.ca/lbrr/archives/qc%20926.45.c22%20e78%202003-eng.pdf
in Klaassen et al. (2003), we also note substantial evidence that some of the thresholds used in this study were also exceeded during the December 2013 ice storm event in the Greater Toronto Area.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 47:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015, Figure ES-1 Example Maps Based on Risk Ratings for High Heat, Freezing Rain and Lightning

It appears from the maps that there may be a correlation between tree density and High Ambient Temperatures, Freezing Rain and Lightning risk rating. Please provide a vegetation density map as well from the 1960s and 2014. [sic]

RESPONSE (PREPARED BY AECOM/RSI):

The Risk Assessment Matrix (p805-806) should be used alongside the commentary in Section 5 of the report (pg 695-706 of PDF) to interpret observed mapping trends in Figure ES-1.

AECOM did not produce vegetation density maps because the scope of the study did not include mapping historic vegetation density. Forensic assessment was limited to analysis of climate and outage data.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 48:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015

How often has THESL experienced, “ice storms (up to 25 mm) and high winds (up to 90 km/h) in the past.” Please provide yearly data in a table format.

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 1B-Hann-7.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 49:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015

a) How does this statement “These events are projected to continue in the future, but continue to occur on a less than annual, or even decadal frequency.” prove as stated throughout the evidence that “extreme storms” are more frequent?

b) Is it the processes from design to construction to maintenance that need to be re-evaluated and addressed in light of the changing urban environment, especially the growth, aging and disease of the urban forest? If yes, what action is being undertaken?

RESPONSE:

a) The statement quoted refers to the general category of “Freezing Rain, Ice Storms, High Winds and Tornados – Overhead and Feeder Assets.” Please refer to Exhibit 2B, Section D, Appendix D, Table 3-2 for a breakdown of projected climate parameters that contribute to extreme weather conditions similar to the recent extreme weather events listed in Exhibit 2B, Section A4, Table 4. The projections are that the occurrence of these parameters will increase in the future. Please refer to Exhibit 2B,
Section D, Appendix D for more details.

b) Following the study referenced, Toronto Hydro developed a climate change adaptation road map, along with initiatives relating to climate data validation, review of equipment specifications, and review of the load forecasting model. As part of this road map, Toronto Hydro reviewed and updated major equipment specifications in 2016 to adapt to climate change, including the adoption of breakaway links in tree-covered areas for residential customers with overhead service connections, intended to facilitate faster restoration after extreme weather and prevent damage to customer-owned service masts. For more information on Toronto Hydro’s climate adaptation road map please refer to Exhibit 2B, Section D2.1.2.

Additionally, Toronto Hydro recognizes that the City of Toronto’s tree canopy, along with factors such as age, invasive species, and disease, is a risk to system reliability. Toronto Hydro manages this risk through programs such as the Preventative and Predictive Overhead Line Maintenance program, and in particular the Vegetation Management segment (Exhibit 4A, Tab 2, Schedule 1, Section 7), the Overhead System Renewal program (Exhibit 2B, Section E6.5), and the Area Conversion program (Exhibit 2B, Section E6.1).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 50:

Reference(s): Exhibit 2B, Section D, Appendix D, Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment Application of the Public Infrastructure Engineering Vulnerability Assessment Protocol to Electrical Distribution Infrastructure Final Report - Public 6031-8907 June 2015

The study took into account the environment of “road salt” on the poles, yet did not include the changes in the urban forest which appears to have a much larger impact on the reliable operation of the system. What is the opinion of THESL on the changing urban forest and what is being done to mitigate the interruptions these changes causes?

RESPONSE:

Toronto Hydro continues to collaborate with the City of Toronto to develop mutually beneficial clearances and maintenance practices to improve resiliency and promote the urban tree canopy. For more details, please refer to Exhibit 4A, Tab 2, Schedule 1, Section 7, for Toronto Hydro’s vegetation management segment.
INTERROGATORY 51:

Reference(s): Exhibit 2B, Section D, Appendix D, p. 10, 11

Fuses and Circuit breakers are in typical stations. What work has been done to coordinate the fuses on the feeders to prevent interruptions that should be captured that affect only a few customers going back to the station switch and taking out many customers?

RESPONSE:

Toronto Hydro’s Construction Standards and Standard Design Practice prescribe fusing requirements for feeders to ensure protection coordination with station circuit breakers and to limit the number of customers impacted by an interruption. Construction Standards and Standard Design Practice are adhered to in all construction on Toronto Hydro’s distribution system.

Prior to the execution of any capital or maintenance work at a station, Toronto Hydro reviews station and feeder protection to ensure proper coordination of protective devices such as breakers and fuses. In addition, prior to connecting a customer-owned substation to its system, Toronto Hydro reviews the customer’s breaker and fuse specifications to ensure coordination with protective devices on Toronto Hydro’s distribution system and to minimize the number of customers impacted by an interruption.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 52:

Reference(s): Exhibit 2B, p. 17

Load projections are provided by Former Toronto and Horseshoe stations. Please provide the Number of interruptions, number of customer interruptions and durations and customer durations by station feeders for 2008-2017 in table format.

RESPONSE:

Based on the load projection referenced in the question, Toronto Hydro is able to provide the information requested broken down by Former Toronto and Horseshoe stations for 2008-2017.

Table 1: Number of Interruptions

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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Former Toronto</td>
<td>230</td>
<td>192</td>
<td>174</td>
<td>197</td>
<td>132</td>
<td>186</td>
<td>140</td>
<td>137</td>
<td>145</td>
<td>126</td>
</tr>
<tr>
<td>Horseshoe</td>
<td>1,618</td>
<td>1,563</td>
<td>1,990</td>
<td>1,741</td>
<td>1,464</td>
<td>1,784</td>
<td>1,749</td>
<td>1,219</td>
<td>1,304</td>
<td>1,097</td>
</tr>
</tbody>
</table>

Table 2: Number of Customer Interruptions

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Former Toronto</td>
<td>178,580</td>
<td>154,448</td>
<td>194,336</td>
<td>168,098</td>
<td>94,683</td>
<td>126,464</td>
<td>108,655</td>
<td>106,197</td>
<td>91,943</td>
<td>89,369</td>
</tr>
<tr>
<td>Horseshoe</td>
<td>1,024,692</td>
<td>970,705</td>
<td>1,034,847</td>
<td>975,297</td>
<td>906,076</td>
<td>915,837</td>
<td>909,515</td>
<td>974,789</td>
<td>967,244</td>
<td>1,001,473</td>
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</tbody>
</table>
### Table 3: Sum of Durations of Interruptions

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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Former Toronto</td>
<td>32,720</td>
<td>23,395</td>
<td>30,046</td>
<td>32,125</td>
<td>22,713</td>
<td>58,708</td>
<td>28,744</td>
<td>21,779</td>
<td>31,523</td>
<td>32,669</td>
</tr>
<tr>
<td>Horseshoe</td>
<td>307,013</td>
<td>298,080</td>
<td>393,321</td>
<td>363,515</td>
<td>290,002</td>
<td>378,735</td>
<td>345,700</td>
<td>268,776</td>
<td>259,653</td>
<td>227,824</td>
</tr>
</tbody>
</table>

### Table 4: Number of Customer Hours Interrupted

<table>
<thead>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Former Toronto</td>
<td>124,960</td>
<td>223,196</td>
<td>188,931</td>
<td>213,381</td>
<td>139,716</td>
<td>135,539</td>
<td>145,891</td>
<td>120,008</td>
<td>160,113</td>
<td>191,061</td>
</tr>
<tr>
<td>Horseshoe</td>
<td>722,926</td>
<td>723,540</td>
<td>709,656</td>
<td>793,428</td>
<td>592,699</td>
<td>691,883</td>
<td>590,646</td>
<td>668,804</td>
<td>562,694</td>
<td>561,400</td>
</tr>
</tbody>
</table>
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 53:
Reference(s): Exhibit 2B, Section D, Appendix D, p. 34

Are trees trimmed properly to prevent mid span contact?

RESPONSE:
Yes, Toronto Hydro’s trees are trimmed to prevent mid span contacts with distribution lines. Trees and branches are pruned according to minimum clearance standards based on American National Standards Institute (“ANSI”) A300 – Standard Practices for Trees, Shrubs and other Woody Plant Maintenance, and the City of Toronto Forestry Pruning Guidelines. Please refer to Exhibit 4A, Tab 2, Schedule 1, Section 7 for further details on Toronto Hydro’s Vegetation Management / Tree Trimming practices.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 54:

Reference(s): Exhibit 2B, Section D, Appendix D, p. 34

Are the conductors sagged and tensioned properly to prevent mid span contact?

RESPONSE:

Yes.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 55:
Reference(s): Exhibit 2B, pg. 35, 36

a) What is the CSA standard for wind load with overload?

b) If they are 120 km/h or greater, why are “wind gusts at 90 km/h and 120 km/h were judged to be a high risk to overhead feeder systems.” since the system is design to withstand this external loading?

RESPONSE:

a) Please see Toronto Hydro’s response to 1B-Hann-6.

b) Wind gusts at 90km/h and 120km/h can cause damage to vegetation which can represent a risk to Toronto Hydro’s system. For more details, please refer to Exhibit 2B, Section D, Appendix D, Appendix C – Forensic Analysis of Weather Power Outage Events.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 56:
Reference(s): Exhibit 2B, p. 36

Do the lightning storms cause “electrical” or “mechanical” interruptions? E.g. how many lightning arrestors were damaged, vs fuse links replaced, how many poles were replaced during lightning storms due to a lightning strike vs trees falling on the conductor? Did the lightning storms actually cause the damage to the assets?

RESPONSE:
Lightning storms apply large electrical stresses to Toronto Hydro’s infrastructure and can damage distribution equipment.

Table 1 below provides quantities of electrical distribution equipment damaged by lightning storms which required replacement from 2011-2018 per Toronto Hydro’s records. Please note that the data set below may not be complete as these records only account for equipment returned for investigation.

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th># of Units Damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable, MV</td>
<td>1</td>
</tr>
<tr>
<td>Lightning Arrester</td>
<td>2</td>
</tr>
<tr>
<td>Pole</td>
<td>1</td>
</tr>
<tr>
<td>Switch, 3PH Manual Loadbreak</td>
<td>1</td>
</tr>
<tr>
<td>Switch, SCADA Loadbreak</td>
<td>1</td>
</tr>
<tr>
<td>Transformer, Padmount</td>
<td>4</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>Equipment Type</th>
<th># of Units Damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer, Polemount</td>
<td>23</td>
</tr>
<tr>
<td>Transformer, Submersible</td>
<td>4</td>
</tr>
</tbody>
</table>
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 57:
Reference(s): Exhibit 2B, pg 49

Why does THESL state throughout the evidence and public consultation that there are and will be more extreme weather while the consultants report states “These events are projected to continue in the future, but continue to occur on a less than annual or even decadal frequency. More severe ice storms (60 mm), high winds (over 120 km/h) and tornadoes (EF1+) have been extremely rare in the past, and while there is a lack of scientific consensus on projected future frequencies for these extreme events, they are likely to remain rare in the future.”?

RESPONSE:
Please refer to Toronto Hydro’s response to interrogatory 2B-Hann-49 part (a).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 58:

Reference(s): Exhibit 2B, pg 49

a) Is THESL planning to implement the recommendation in Affected Infrastructure 10

“Toronto Hydro is already experiencing outages caused by tree contacts and is
planning to increase its vegetation management activities. This study supports the
need for increased tree trimming practices around overhead power lines and use
of tree proof conductors in areas where outages due to tree contacts have been
frequent.”?

b) When and by

c) How much?

RESPONSE:

a) As stated in the AECOM report: “Toronto Hydro […] is planning to increase its
vegetation management activities.” For further information on Toronto Hydro’s
vegetation management practices, please refer to Exhibit 4A, Tab 2, Schedule 1,
Section 7.

Over the 2020-2024 period, Toronto Hydro plans to install tree-proof conductors in
heavily treed areas to reduce vegetation contact risks as part of planned area rebuilds
or reactively upon failure. Please refer to Exhibit 2B, Section E6.5 for more
information about Toronto Hydro’s Overhead System Renewal program and to Exhibit

Panel: Distribution System Capital and Maintenance
2B, Section D2.1.2, pages 7-8 for further information on Toronto Hydro’s ongoing efforts to renew and enhance its system to increase resiliency to changes in the weather and climate.

b) Please see response to part (a).

c) Please see response to part (a).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 59:
Reference(s): Exhibit 2B, Pg no number Pg 769 of pdf

a) How many crews were available to respond on days with 20 or more reports?

b) What impact did this have on restoration time?

c) Were the interruptions restored in most customers out order, or by the time the call came in, or by restoring everything in an area or any combination of the above?

RESPONSE:

a) For the 2000 to 2006 period, Toronto Hydro does not have a record of how many specific crews were available for each of the events. Please refer to Toronto Hydro’s response to interrogatory 2B-Hann-62 (a).

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Hann-62 (a).

c) Please refer to Toronto Hydro’s response to interrogatory 2B-Hann-62 (c).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 60:

Reference(s): Exhibit 2B, Pg no number Pg 770 of pdf

a) Is there a recurring weather cycle of say 7 years?

b) Is this related to tree growth/trimming? Reference “It may also be possible to anticipate a particularly severe damage year since the “major” events producing over 150 reports tend not to occur in isolation but usually occur in years with a number of less severe but still significant events, although the consistency of this pattern requires further research”.

RESPONSE (PREPARED BY AECOM/RSI):

a) The period of record available for consistent power outage incident data (2000-2006 inclusive) was of insufficient length to determine if a regular multi-year cycle is present. Due to the focus in the analyses on individual case studies and the fact that it did not include assessment of multi-year cycles, no investigation of recurring weather cycles is possible under the constraints of the original assessment, scope, and available data.

Furthermore, current Best Practices employed for the calculation of return-periods for extreme weather events is to treat events within each individual year as statistically independent. This means that the occurrence of an event in one year does not affect the probability of the same type of event occurring in other years.
For more detailed descriptions of return-period calculation methods for climatic extremes, see the National Building Code of Canada, Appendix C “Climatic and Seismic Information” (NRC 2015), or CSA PLUS 4013-12 TECHNICAL GUIDE - Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners (CSA 2012).

b) Determination of any links to tree growth cycles or Toronto Hydro’s tree maintenance program is well beyond the scope of work. To fully examine this question would require an analysis of the interaction between high-impact weather events and Toronto Hydro’s maintenance and response programs. The purpose of the forensic assessment was to help determine impact thresholds for the purposes of the PIEVC risk assessment and was not meant to assess Toronto Hydro staff’s performance in responding to these events.

To clarify, the statement quoted in this question is in reference to the “clustering” of similar high-impact events in adjacent days or weeks within the same season. The appendix of the Project Report provides an example of this regarding large-scale windstorms; “Fall and spring large scale wind storms will occasionally occur in series” with the September 29 to November 13, 2005 wind storm series provided as an example.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 61:
Reference(s): Exhibit 2B, Pg no number Pg 770 of pdf

Did the consultant challenge what the actual root cause was of lightning reported interruptions? What was the result of that challenge? Reference “Lightning - Customer interruptions due to lightning striking the distribution system, resulting in an insulation breakdown and/or flash-overs Pg 25 of RRR_Electricity_20130101” [sic]

RESPONSE (PREPARED BY AECOM/RSI):
No. None of the statements within the forensic analysis were meant to challenge the stated mechanism associated with lightning related interruptions. The forensic analysis found indications that even in cases where other damage mechanisms are present (i.e., wind, extreme rainfall), that lightning related impacts were still a major contributor to the total number of outage incidents associated with a given weather event.

From the Report Appendix: “Even for storms which included extreme rainfall and high winds [sic] related impacts, lightning appeared to be the dominant factor in producing outages.” [emphasis added]
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 62:

Reference(s): Exhibit 2B, Pg no number Pg 785 to 788 of pdf

“ The majority of power outage events identified in the 2000-2006 period were extended events lasting up to 48 hours, representing the need for sustained operational response, but the characteristics of these events differed depending on season:”

a) What impact did the available crews have on restoration time?

b) What impact did the time of day or day of week have on the restoration time?

c) What impact did dispatch process have on restoration time?

RESPONSE:

a) For the 2000 to 2006 period, Toronto Hydro does not have a record of how many specific crews were available for each of the events, nor is there a record of any exceptional circumstances related to crew availability that impacted specific restoration times. In general and up to a point, having more qualified crew resources available to respond to an event will reduce restoration time.

b) For the 2000 to 2006 period, Toronto Hydro does not have a record of the specific impact that time of day or time of week had on restoration time, nor is there a record of any exceptional circumstances related to time of day/week that impacted specific restoration times. In general, initial response to power outages is quicker when the
event occurs during regular working hours (Monday to Friday), as crews that are already engaged with planned work can be immediately redeployed to support 24/7 response crews with restoration efforts.

c) For the 2000 to 2006 period, Toronto Hydro does not have a record of any exceptional circumstances related to contemporaneous dispatch processes that impacted specific restoration times. Toronto Hydro dispatches events based on a number of factors, including relative event priority and availability of qualified resources.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 63:
Reference(s): Exhibit 2B, Pg no number Pg 785 to 788 of pdf

“Overall, larger metropolitan LDCs appear to be more vulnerable to climatic events than smaller LDCs, particularly when considering overall restoration times; this is likely due a culmination of factors, not the least of which include the state and age of equipment, difficulty of access for system repair in an urban environment, and the relative proportion of staff available with respect to total number of customers and the size of a geographical area of responsibility.” How is this conclusion supported in the evidence that “age of equipment” is an issue?

RESPONSE (PREPARED BY AECOM/RSI)
The statement quoted within the question describes a series of hypotheses, listing potential reasons why large metropolitan LDCs may be subject to longer restoration times for customers than rural or small municipal systems.

The question is focused on one cause from the list which is not explicitly supported through the forensic analysis – a forensic analysis which focuses on the weather events themselves and not the structural/infrastructure factors contributing to sensitivity of the infrastructure.

However, aging and weathering of infrastructure has been identified as a key factor which increases infrastructure sensitivity to weather and climate related impacts. For example:

- From the PIEVC Engineering Protocol (Engineers Canada, 2016), under “Step 4 – Engineering Analysis”, practitioners are explicitly directed to include assessment of
the “change in capacity arising from aging and normal wear and tear of the infrastructure”.

- From the special IPCC report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (IPCC 2012) "...resource management agencies now stress climate change as one of many trends such as growing demand for resources, environmental constraints, aging infrastructure, and technological change that, particularly in combination, could require changes in investment plans and business models..." (IPCC, 2012; emphasis added)
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 64:

Reference(s): Exhibit 2B, Pg no number Pg 785 to 788 of pdf

“Certain regions within the city appear to be more susceptible to weather related power outages; potential regional differences in vulnerability should be investigated further. It is not clear at this time if these vulnerabilities are due to aging infrastructure, proximity to aged canopies, difficult to access infrastructure (e.g. back-lots) or some other combination of factors.” What action has been taken with respect to this conclusion?

RESPONSE:

Following the completion of the Climate Change Vulnerability Assessment, Toronto Hydro developed a climate change adaptation road map that included initiatives relating to climate change data validation, review of equipment specifications, and review of the load forecasting model. Please refer to Exhibit 2B, Section D2.1.2 for more details.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 65:
Reference(s): Exhibit 2B, Pg no number Pg 785 to 788 of pdf

“Changes in tree health conditions such as disease and pests may also be playing a role in increasing sensitivity to damage, as suggested by analyses of the December 2013 ice storm.

These represent very complex interactions, since the extent of certain disease and pests will also be affected by changing climate regimes, and their interaction with the structural integrity of trees and limbs is still unknown.”

What is vegetation management doing to address “Changes in tree health conditions such as disease and pests may also be playing a role in increasing sensitivity to damage” and that the trees (canopy) grow taller and older each year?

RESPONSE:
Toronto Hydro uses certified utility arborists for vegetation management activities who have training, knowledge, and certification in the practice of arboriculture and who consider factors such as the species, health, and aesthetics of a tree during trimming.

Please refer to Exhibit 4A, Tab 2, Schedule 1, which discusses Toronto Hydro’s vegetation management program in more detail.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 66:

Reference(s): Exhibit 2B, Pg no number Pg 842 844 of pdf

“Is the design of the THESL for ice loading based on the design strength of conductors, poles and pole hardware or the strength of tree branches as stated “load is based on tree branches that usually start to break with a 15 mm of freezing rain.”? [sic]

RESPONSE (PREPARED BY AECOM/RSI)

This risk is related to tree branches breaking, and then coming into contact with Overhead Feeders in Loop Configuration, as a result of freezing rain, rather than Toronto Hydro’s design for ice loading.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 67:

Reference(s): Exhibit 2B, Pg no number Pg 842 844 of pdf

a) Is the risk “The future overall “capacity” will decrease (or vulnerability to damage will increase) because of new or exacerbated disease and pest conditions and possibly, because of the tree faster growth (extended growing season, more branches)” or on proper vegetation management?

b) Will proper and appropriate vegetation management mitigate this risk? Why and by how much?

RESPONSE:

a) As mentioned in Section B.4, Appendix B of the Climate Change Vulnerability Assessment report, the complex interaction between accelerated growth rates, disease and pest regimes, and the resulting changes in vulnerability to adjacent infrastructure have only recently been identified and are not well understood. Please refer to the response to interrogatory 2B-Hann-65 and Exhibit 4A, Tab 2, Schedule 1, page 27 in respect of Toronto Hydro’s Vegetation Management program and how the program manages risks, such as tree health and growth patterns. Specifically, Exhibit 4A, Tab 2, Schedule 1, Figure 13 illustrates the impact vegetation management has on reducing the number of tree-caused interruptions.

b) See response to part a).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 68:

Reference(s): Exhibit 2B, Section E2, p. 14, lines 3-8

Given the consultants report and statements on lack of accurate/complete records, using newspaper reports for numbers of customer and focus on tree branches being the cause of interruptions, [sic]

a) how confident is THESL that defective equipment is a prominent cause?

b) That aging equipment is the main root cause of defective equipment?

c) That the main root cause is not tree branches causing fuses to operate?

d) Please provide evidence of training in cause code identification for reporting staff.

e) Please provide stores information of damaged equipment numbers that have been replaced as part of an interruption event.

RESPONSE:

a) The consultant report used newspaper reports and other sources for confirmation of restoration times (for other LDCs such as Veridian, Whitby PUC) and for additional weather related information. The consultant’s report does not bring into question Toronto Hydro’s record keeping, and defective equipment is without a doubt a prominent cause of interruptions on Toronto Hydro’s system. Toronto Hydro follows all record keeping requirements as set out by the OEB in the “Electricity Reporting and Record Keeping Requirements”. Please refer to Exhibit 1B,
Tab 2, Schedule 4, Table 2. Defective Equipment accounts for 36 percent and 44 percent of SAIFI and SAIDI, respectively. Defective Equipment is the single largest contributor to reliability and interruptions on the distribution system.

b) Please refer to Toronto Hydro’s response to interrogatory 1B-Hann-37.

c) Tree Contacts can cause fuses to operate as part of the system’s protection scheme. These outages are categorized as Tree Contacts if there is sufficient evidence to show this was the cause. Please refer to Exhibit 1B, Tab 2, Schedule 4, Table 2. Tree Contacts contributed, on a five-year average, 8 percent and 13 percent to SAIFI and SAIDI, respectively.

d) All Power System Controllers, beginning at the time of their apprenticeships, are trained on the Interruption Tracking Information System (ITIS) which includes a review of the CEA Classification & Codes and an explanation on how to apply the causes.

Toronto Hydro’s “stores” would issue equipment to replace defective equipment following an interruption. Please see below for examples of the types of equipment that stores would issue.

<table>
<thead>
<tr>
<th>POLE 60' WESTERN RED CEDAR CLASS 1 ASPER THES SPEC D-129-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFORMER PADMOUNTED 1PH 167KVA4160GRDY/2400 240/120V LOOP 2 LINESWITCHES CURRENT LIMITNG AND BAYONETFUSES LOW PROFILE DEAD FRONT AS PERSPEC DT-PAD-01R2</td>
</tr>
<tr>
<td>TRANSFORMER SUBMERSIBLE STAINLESS STEEL1PH 100KVA 27600GRDY/16000-240/120V 2LINE SWITCHES ONE LV BREAKER HV CURRENTLIMITING FUSE AND FUSE LINK. AS PER THESSPEC DT-SUB-03R2</td>
</tr>
</tbody>
</table>
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 69:
Reference(s): Exhibit 2B, Section E2, p. 21, lines 1-6

What was the life span of the mechanical meters that were replaced by the smart meters?

RESPONSE:
The useful life range of the electro-mechanical meters was 25-35 years as per the 2010 Asset Depreciation Study conducted by Kinectrics for the Ontario Energy Board.¹

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 70:
Reference(s): Exhibit 2B, Section E2, p. 21, lines 1-6

Why is the life span expected to be 15 years for the smart meters?

RESPONSE:
The expected lifespan of 15 years is based on the 2010 Asset Depreciation Study conducted by Kinectrics for the Ontario Energy Board. This report states that the useful life range of a smart meter is 5-15 years.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 71:

Reference(s): Exhibit 2B, Section E2, p. 21, p. 23, lines 1-6

What is the life span of the new replacement meters?

RESPONSE:

The new replacement meters will have the same life span as the existing smart meters.

Please refer to Toronto Hydro’s response to interrogatory 2B-Hann-70 regarding the lifespan of smart meters.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 72:

Reference(s): Exhibit 2B, Section E2, p. 22, p. 23, lines 1-21, lines 1-17

a) How many poles (by year) failed due to age from 2008 to 2017 on days without storms?

b) How many poles (by year) failed on days with storms where the pole was broken due to strictly wind or ice load on the conductor?

RESPONSE:

a) The following table provides the number of pole failures that resulted in interruptions on non-major event days. Please note that in addition to the poles listed in the table, Toronto Hydro identifies a number of other poles each year that have either failed or are determined to be at the end of their serviceable life, but that have not caused an interruption. For more information on this, please refer to Toronto Hydro’s response to interrogatory 4A-Hann-87.

Table 1: Pole Failures (2008-2018 with no Major Event Days)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>12</td>
</tr>
<tr>
<td>2009</td>
<td>8</td>
</tr>
<tr>
<td>2010</td>
<td>4</td>
</tr>
<tr>
<td>2011</td>
<td>8</td>
</tr>
<tr>
<td>2012</td>
<td>6</td>
</tr>
<tr>
<td>2013</td>
<td>4</td>
</tr>
<tr>
<td>2014</td>
<td>19</td>
</tr>
<tr>
<td>2015</td>
<td>12</td>
</tr>
</tbody>
</table>
b) Toronto Hydro does not have that information, as Toronto Hydro’s systems do not track failures on the basis of “strictly wind or ice load on the conductor.”

<table>
<thead>
<tr>
<th>Year</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>3</td>
</tr>
<tr>
<td>2017</td>
<td>7</td>
</tr>
<tr>
<td>2018</td>
<td>7</td>
</tr>
</tbody>
</table>
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 73:

Reference(s): Exhibit 2B, Section E2, p. 22, p. 23, lines 1-21, lines 1-17

In the photo in Figure 12: “Deterioration 1 at the base of a pole” provided,

a) What is the estimated % reduction in load carrying capacity? What is the estimated % reduction of load carrying capacity for the “approximately 11,000 poles in each of the 6 HI4 ("material deterioration") and HI5 ("end-of-serviceable life") condition bands."

b) For the conductor sizes and class of pole used by THESL,
   i) what are the maximum span the poles can be set at according to maximum design loads with overload?
   ii) What is the average span on the THESL system?

RESPONSE:

a) The photo of the pole in Exhibit 2B, Section E2, p. 23, Figure 12 was included for illustrative purposes. For this reason, the estimated percent reduction in load carrying capacity of this specific pole cannot be provided.

Toronto Hydro has not calculated percent reduction in load carrying capacity for the approximately 11,000 poles in HI4 and HI5 bands. Such a calculation would be complex as multiple variables are involved such as span between poles, conductor tension, pole height, and pole strength.
b)  
i) The maximum allowable span between poles for regular span construction is 38 metres. The maximum allowable span between poles for long-span construction is 60 metres, which is only constructed when regular span construction cannot be achieved.

ii) The average span between poles is 27 metres.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 74:

Reference(s): Exhibit 2B, Section E2, p. 24, lines 2-7

a) How many pole top transformers (by year) failed due to age from 2008 to 2017 on days without storms or high temperatures?

b) How many pole top transformers (by year) failed on days with storms where the transformer failed without any external forces?

c) How many transformers (by year) failed on high temperature days?

RESPONSE:

a) Toronto Hydro is unable to provide the data as specifically requested (i.e. for the length of time, excluding storms and high temperatures, by age) due to system and data limitations. However, the combination of information provided in (i) Exhibit 2B, Section E6.5, Figure 7 at page 9, (ii) part (b) of this response, and (iii) part (c) of this response, may be used to infer what the data set would look like.

i) Exhibit 2B, Section E6.5, Figure 7 at page 9, provides the analysis that was conducted as part of Toronto Hydro’s Quality Program on a substantial subset of failed pole top transformers from 2013-2017. That analysis divides failures by age and Toronto Hydro has no reason to believe that a broader subset of data (either by number of transformers investigated, or broader period of time e.g., 2008-2017) would yield different results.
ii) Part (b) of this response shows that an extremely low number of transformers (i.e. approximately only 1 per year) fail during storm events without any external forces being applied. As a result, the findings of the analysis discussed in (i) are not expected to change materially if failures during storms are excluded.

iii) Part (c) of this response shows that relatively few transformers (i.e. 8 annually on average) fail during high temperature days. As a result, the findings of the analysis discussed in (i) are not expected to change materially if failures during high temperature days are excluded.

b) Please see the table below. Toronto Hydro has experienced one transformer failure annually (on average) where the transformer failed, during a storm event, but did so without any external forces being applied.

Table 1: Number of Pole Top Transformer Failures

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Failures</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: For the purposes of this response, Toronto Hydro has interpreted the terms “storm” and “failures” to mean: (i) “Storms” are major events that occurred on “Major Event Days” as defined in Exhibit 1B, Tab 2, Schedule 4, at page 5; and (ii) “Failures” are interruptions caused by defective (transformer) equipment on Major Event Days.

c) Please see the table below. Toronto Hydro does not have a definition for “high temperature day”. For the purposes of this response, Toronto Hydro is providing the number of transformer failures that resulted in an interruption, categorized by the ambient temperature on the day of the interruption (i.e. recorded temperature in Toronto) for what could commonly be considered to be “high temperatures” in Toronto.
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 30°C</td>
<td>1</td>
<td>0</td>
<td>28</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 75:
Reference(s): Exhibit 2B, Section E2, p. 24, lines 2-7

a) What is the performance (by age) of pole top transformers younger and older than 35 years on non-storm and non-high temperature days?

b) Are they failing at the same rate?

c) What are the modes of failure?

RESPONSE:

a) Exhibit 2B, Section E6.5, Figure 7 at page 9 provides a summary of the failure modes of overhead transformers on the basis of their age profile, which includes an overview of failure modes for transformers older and younger than 35 years old.

b) As per Exhibit 2B, Section E6.5, Figure 7 at page 9, older transformers typically fail at a higher frequency than younger transformers.

c) Please see part (a).
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 76:

- Reference(s): Exhibit 2B, Section E4, p. 13, lines 6-15
  Pag 939, pg 1317 line 12-21

  a) How does Feeder Automation operations input to MAIFI reporting?
  b) What impact did Feeder Automation have from 2015-2018 on MAIFI?

RESPONSE:

a) The goal of feeder automation is to reduce outage restoration time by allowing faster sectionalization of feeders. The speed with which this is achieved in each instance will determine how outages are reported (i.e. depending on whether an outage is sustained or momentary, it would be counted as SAIFI or MAIFI, respectively).

b) The impact of the Feeder Automation program on MAIFI during 2015-2018 was not tracked.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 77:

Reference(s): Exhibit 2B, Section E5.1, p. 5, line 1-13

a) What accounted for the dramatic increase in customers from 2007 to 2015 (Figure 2: Historical and Forecast Number of Toronto Hydro Customers)?

b) Where were the new customers predominantly connected?

c) Were these new customers the result of new construction or changes in metering (from central to unit metering)?

d) How many were new construction, how many changes in metering by year?

RESPONSE:

a) New connections account for the increase in customers from 2007 to 2015. The City of Toronto has experienced, and continues to experience, a surge in residential and non-residential development, as referenced in page four of Exhibit 2B, Section E5.1

b) New customers were predominantly connected in the downtown area.

c) The customer count includes new connections and any increase/decrease from changes in metering.
d) Changes in metering (from central to unit metering) only account for 4.03 percent of the increase in the customer numbers on average.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 78:

Reference(s): Exhibit 2B, Section E5.3, p. 12, line 11-25

a) How will feeder automation (2B-hann-96) Reduce the switching time? What impact will it have on SAIDI and CAIDI?

RESPONSE:
The Feeder Automation program will reduce the switching time by installing Supervisory Control and Data Acquisition (SCADA) switches in the distribution system that can operate autonomously. The use of automation typically reduces the duration of outages on feeders to under five minutes as compared to the typical restoration time of 30 minutes on remote operation of SCADA switches and three hours on feeders that require manual switching by crews. Feeder Automation is expected to have a positive impact on SAIDI and CAIDI. Please refer to Exhibit 2B, Section E7.1.3.1, sub-section 2 for more details.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 79:

Reference(s): Exhibit 2B Section E6.2, p. 17, p. 18

Figure 13: Age of Transformers 1 at Time of Failure

a) Why does external, other and unknown stop at age 35?

b) It would be expected that external damage, other and unknown would happen randomly, is the data being reported properly? [sic]

RESPONSE:

a) The premise of the question is incorrect. As shown in Exhibit 2B, Section E6.2, Figure 13, there are some 40+ year-old transformers that have failed as a result of having exceeded their useful life, due to external damage, or other causes.

b) Yes.
RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 80:
Reference(s): Exhibit 2B, Section E7.1, p. 7, line 1-13

a) What is being done to prevent trunk outages interruptions?

b) What is being done to prevent the interruptions on the feeder being captured by the protective device at the station?

RESPONSE:

a) Vegetation management and the installation of tree-proof conductors in areas with high tree density are currently being used to prevent feeder trunk outages.

b) Toronto Hydro is currently studying the installation of re-closers on the feeder trunk to address feeders that are experiencing numerous momentary interruptions. In order for this project to be successful, a workable solution for the coordination of the station breaker relay, re-closer, and downstream fuses must be developed. This project is still in the pilot stage.
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 3:
Reference(s): Exhibit 2B, Section A4, p. 21, Table 5: 2020-2024 Custom Performance Scorecard Measure

In the reference, Toronto Hydro is proposing 15 custom measures for the 2020-2024 plan period with associated targets. Of these, the targets for three measures - System Health (Asset Condition) — Wood Poles, Average Wood Pole Replacement Cost, and Vegetation Management Cost per Km are presents as "Monitor"

It appears that Toronto Hydro's reason for not having a target for these measures is because they are new measures are new and therefore baseline data does not exist.

a) Please explain if what Toronto Hydro is saying is that it does not have a 5-year historical data on these measures (such as Average Wood Pole Replacement Cost) or that it has not developed an index to track performance in these measures?

RESPONSE:

a) As stated in Exhibit 2B, Section C – Performance Measurement at page 4, the utility does not have the full data set, or the operational experience with these specific measures, to establish targets or reliable baseline information at this time. Nonetheless, Toronto Hydro sees value in including these measures in its scorecard as a way to track the performance of its capital plan and the supporting maintenance program.
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 4:
Reference(s): Exhibit 2B, Section D2, p. 17, Figure 9

"As of 2017, over a quarter of poles are beyond their useful life of 45 years, and a significant percentage of pole top transformers are at or approaching their useful life of 35 years. Without proactive intervention, Toronto Hydro projects that the percentage of pole top transformers having reached or exceeded useful life will significantly increase from 14 percent as of 2017 to approximately 40 percent by 2024."
a) What will be the share of wood poles beyond their useful life at the end of the plan if the proposed investment plan is approved by the OEB?

b) What will be the share of wood poles beyond their useful life at the end of the plan under historical level of investment (2015-2019)?

c) What is the useful life or age assumed for pole top transformers?

RESPONSE:

a) The share of wood poles beyond their useful life at the end of the plan is not available as Toronto Hydro has not identified the specific assets to be replaced over the full five-year period.

b) The share of wood poles beyond their useful life at the end of the plan under historical investment is not available as Toronto Hydro has not identified the specific assets that would be replaced under historical levels of investment.

c) The useful life used for pole top transformers is 35 years.
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 5:

Reference(s): Exhibit 2B, Section D2, p. 18, Figure 10

Figure 1: Asset Condition Assessment of Overhead Assets as of 2017

- a) What is the average age of wood poles classified as HI5, HI4, and HI3?
- b) Please provide a chart in a tabular form showing the share of wood poles and overhead switches that Toronto Hydro projects to be in HI5, HI4, and HI3 condition at the end of the plan period (2024) assuming the proposed investment plan is approved
- c) Please provide a chart as in #2 above under the assumption that Toronto Hydro maintains historical level of investment (2015-2019)

RESPONSE:

a) Please see the table below which gives the average age for each Health Index category

<table>
<thead>
<tr>
<th>Health Index</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI5</td>
<td>0%</td>
</tr>
<tr>
<td>HI4</td>
<td>20%</td>
</tr>
<tr>
<td>HI3</td>
<td>40%</td>
</tr>
<tr>
<td>HI2</td>
<td>60%</td>
</tr>
<tr>
<td>HI1</td>
<td>80%</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
Table 1: Average Age for Each Health Index Category

<table>
<thead>
<tr>
<th>Health Index Category</th>
<th>Average Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI3</td>
<td>55</td>
</tr>
<tr>
<td>HI4</td>
<td>57</td>
</tr>
<tr>
<td>HI5</td>
<td>49</td>
</tr>
</tbody>
</table>

Please note that poles in HI4 and HI5 are determined to be in those bands as a result of condition. Without the presence of condition criteria (representing notable deficiencies), even the oldest poles (e.g. those exceeding 80 years of age) will not be categorized beyond HI3.

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (a).

c) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (a).
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 6:

Reference(s): Exhibit 2B, Section D2, p. 32, Figure 20

Figure 1: Asset Condition Assessment of Secondary Network Assets

"ACA results show that approximately 19 percent of Toronto Hydro's network vaults and 13 percent of network transformers have at least moderate deterioration as of 2017. With over 60 network vaults in HI3 condition, approximately 10 in HI4 condition, and approximately 30 in HI5 condition (i.e. "end of serviceable life"), Toronto Hydro expects network vault replacement will continue to be a significant driver of both reactive and planned investment through 2024.

a) Please provide a chart in a tabular form showing the share of Network Transformers and Network Vaults that Toronto Hydro projects to be in HI5, HI4 and HI3 condition at the end of the plan period (2024) if the proposed investment plan is approved.
b) Please provide a chart as in #8 above under the assumption that Toronto Hydro maintains historical level of investment (2015-2019)

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (a).

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 (a).
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 7:

Reference(s): Exhibit 2B, Section D2, pp. 36-37, Figure 24

"Figure 24 provides the age demographic distribution of major station assets. As of 2017, 40 percent of Toronto Hydro's switchgear, 51 percent of power transformers, 13 percent of outdoor breakers, and 35 percent of DC battery systems are operating at or beyond their useful life. Without proactive intervention, the proportion of station assets operating beyond their useful life will continue to increase."

![Figure 1: Stations Assets Demographics as of 2017](image)

- a) What will be the share of Switchgear, Power Transformers and Outdoor breakers beyond their useful life at the end of the plan if the proposed investment is approved?
b) What will be the share of Switchgear, Power Transformers and Outdoor breakers beyond their useful life at the end of the plan, under historical level of investment?

RESPONSE:

a) Under the proposed investment plan 40 percent of Switchgear, 47 percent of Power Transformers, and 0 percent of Outdoor breakers will be beyond their useful life at the end of the plan.

b) Toronto Hydro hasn’t performed an analysis to determine the specific mix of projects that would be executed and hence specific assets that would be replaced under historical levels of investment. Hence, the share of Switchgear, Power Transformers and Outdoor breakers beyond their useful life at the end of plan under historical level of investment is unavailable.
RESPONSES TO POWER WORKERS UNION INTERROGATORIES

INTERROGATORY 8:

Reference(s): Exhibit 2B, Section D2, pp. 38-39, Figure 25

"Figure 25 shows that 90 percent of Toronto Hydro's air-blast circuit breakers, 66 percent of its oil circuit breakers, 58 percent of KSO oil circuit breakers, 56 percent of air-magnetic circuit breakers, 15 percent of SF6 circuit breakers, and 6 percent of vacuum circuit breakers show signs of at least moderate deterioration. Accordingly, renewal of switchgear containing air-blast circuit breakers and oil circuit breakers are heavily targeted in the Stations Renewal Program (Exhibit 2B, Section E6.6). Similarly, standalone outdoor KSO circuit breakers are prioritized for renewal in the proposed program. Figure 25 shows that 33 percent of Toronto Hydro's station power transformers show signs of at least moderate deterioration. The need for transformer renewal is underscored by a recent surge in the number of units requiring reactive replacement."

Figure 1: Asset Condition Assessment of Station Assets
a) Assuming the proposed investment plan is approved, what is Toronto Hydro’s projection of the share of each of the above assets that will be in HI5, HI4 and HI3 at the end of the plan?

b) What is Toronto Hydro’s projection of the share of each of the above assets in HI5, HI4 and HI3 if the company maintains historical level of investment?

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 part (a).

b) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-71 part (a).
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 32:

Reference(s): Exhibit 2B, Section A6, p. 32

Toronto Hydro states that it’s currently undertaking a CIC (customer interruption cost) study.

a) Please provide more about the study.

b) Please provide a copy of any study work plans, charters, or similar guiding documents.

c) Please provide details, including a copy, of any preliminary results of the study.

RESPONSE:

a) The Customer Interruption Cost (CIC) study engaged customers through a survey-based approach to help establish City of Toronto-specific CIC values. Toronto Hydro is currently in the process of completing the study. As part of the study, Toronto Hydro’s customers were surveyed – including residential, small and medium businesses, and large customers (>1MVA) – regarding their reliability experience and potential costs of power interruptions. Although information from the surveys is available, Toronto Hydro must still perform substantial analysis of the results to update the current Event costs and Duration costs used for CIC evaluation and integrate the results into its tools for use in planning procedures.
b) Please refer to Appendix A for the Request for Proposal (RFP) that Toronto Hydro issued which provides details on the scope of work for the study.

c) Please see response to part (a). As the study remains incomplete, preliminary results are not available at this time.
REQUEST FOR PROPOSALS

Number 16P-126

for

the supply of

Customer Interruption Costs Study

To

Toronto Hydro-Electric System Limited

(“Toronto Hydro”)

December 30, 2016
# TABLE OF CONTENTS

1. **INTRODUCTION** .................................................................................................................. 4  
   1.1 Introduction ..................................................................................................................... 4  
   1.2 Sections .......................................................................................................................... 4  
   1.3 Defined Terms ................................................................................................................ 4  

2. **RFP RULES AND PROCEDURES** ...................................................................................... 5  
   2.1 Rules and Procedures ..................................................................................................... 5  
   2.2 Respondents .................................................................................................................. 5  
   2.3 Communications ............................................................................................................ 5  
   2.4 RFP Schedule ............................................................................................................... 5  
   2.5 Questions and Clarifications regarding this RFP .......................................................... 5  
   2.6 Amendments or Supplements to RFP .......................................................................... 6  
   2.7 Submitting the Proposal ............................................................................................... 6  
   2.8 Modifications or Withdrawal of Proposals before Submission Deadline ................. 6  
   2.9 Ownership of Proposals .............................................................................................. 7  
   2.10 Verification of Information .......................................................................................... 7  
   2.11 Clarifications or Supplements to Proposals .............................................................. 7  
   2.12 Evaluation of Proposals ............................................................................................. 7  
   2.13 Selection of Proposals ............................................................................................... 8  
   2.14 Confidentiality ............................................................................................................ 9  
   2.15 No Representations or Warranties .............................................................................. 10  
   2.16 No Damages ................................................................................................................ 10  
   2.17 No Collusion ............................................................................................................... 11  
   2.18 Conflicts of Interest ................................................................................................... 11
2.19 Assignment.............................................................................................................................................. 11
2.20 Governing Law............................................................................................................................................. 11

3. PROPOSAL REQUIREMENTS.......................................................................................................................... 12

4. GOODS/SERVICES REQUIRED .................................................................................................................. 12

5. CONTRACT NEGOTIATIONS ......................................................................................................................... 12
5.1 Contract Terms and Conditions.................................................................................................................. 12
5.2 Contract Negotiations................................................................................................................................... 12
5.3 No Liability .................................................................................................................................................. 13

SCHEDULE A  RFP PROCEDURES ................................................................................................................... 14

SCHEDULE B....................................................................................................................................................... 15

SCHEDULE C  STANDARD TERMS AND CONDITIONS..................................................................................... 23

SCHEDULE C-2 ADDITIONAL TERMS AND CONDITIONS.............................................................................. 34

SCHEDULE D  PROPOSAL COVER SHEET ........................................................................................................ 38

SCHEDULE E  RESPONDENT'S CERTIFICATE .................................................................................................. 39

SCHEDULE F  DEFINED TERMS........................................................................................................................ 41
REQUEST FOR PROPOSALS

1. INTRODUCTION

1.1 Introduction

This RFP is being issued and administered by the Supply Chain Services Department in order to obtain Proposals from one or more Respondents that would result, if accepted by Toronto Hydro, in the successful Respondent(s) entering into negotiations to execute a Contract with Toronto Hydro for the supply of the goods/services as further described herein.

1.2 Sections

This RFP is divided into five (5) sections and schedules, as follows:

1. Introduction
2. RFP Rules and Procedures
3. Proposal Requirements
4. Goods/Services Required
5. Contract Negotiations

Schedule A: RFP Procedures
Schedule B: Proposal Requirements and Goods/Services Required
Schedule C: Standard Terms and Conditions
Schedule C-2: Additional Terms and Conditions
Schedule D: Proposal Cover Sheet
Schedule E: Respondent's Certificate
Schedule F: Defined Terms

1.3 Defined Terms

(a) All capitalized terms in this RFP shall be as defined in SCHEDULE F, unless otherwise defined herein.

(b) Words and abbreviations that have well known technical or trade meanings are used in this RFP in accordance with such recognized meanings.
2. **RFP RULES AND PROCEDURES**

2.1 **Rules and Procedures**

The submission of a Proposal by the Respondent shall be deemed to signify that the Respondent has read, understood and agrees to comply with all of the terms and conditions of this RFP including without limitation all RFP Rules and Procedures as detailed in this Section 2.

2.2 **Respondents**

(a) This RFP is being issued to a limited number of organizations that have been pre-selected by Toronto Hydro. Toronto Hydro reserves the right to contact additional parties regarding this RFP, or issue a separate or supplementary RFP, for this or any related matter, in its discretion and at any time.

(b) A Respondent’s pre-selection signifies that a Respondent has met Toronto Hydro’s minimum requirements and does not mean that the Respondent is on equal footing with other approved Respondents. Notwithstanding a Respondent’s pre-selection, Toronto Hydro reserves the right to consider such criteria as described in Section 2.13 below in selecting or rejecting any Proposal.

2.3 **Communications**

(a) All questions or other communications regarding this RFP, including any notices required hereunder and the submission of Proposals, are to be addressed solely to the Supply Chain Services Department, in writing, to the attention of the Supply Chain Specialist identified in SCHEDULE A.

(b) **Respondents shall communicate only with the Supply Chain Services Department and shall not communicate with any other department or Representative of Toronto Hydro regarding this RFP.**

2.4 **RFP Schedule**

Subject to any modifications in Toronto Hydro's discretion, and subject to all other terms of this RFP, the schedule and timelines set out in SCHEDULE A will apply to this RFP.

2.5 **Questions and Clarifications regarding this RFP**

(a) Upon review of this RFP, Respondents shall immediately notify the Supply Chain Services Department, in writing, of any omissions, discrepancies, ambiguities or details contained in this RFP requiring further clarification.
(b) All questions regarding the RFP shall be made in writing to the Supply Chain Services Department **by no later than 1:59:59 p.m. EST on the Deadline for Submission of Questions in SCHEDULE A.** Questions and responses will be recorded by the Supply Chain Services Department, and may be distributed to all Respondents, in Toronto Hydro's discretion. The Supply Chain Services Department will respond to those questions that, in Toronto Hydro's discretion, provide clarification to this RFP.

2.6 Amendments or Supplements to RFP

Toronto Hydro reserves the right to issue addenda, supplements and make amendments to this RFP at any time, in its discretion. All addenda, supplements or amendments to this RFP shall be delivered to all parties having received a copy of this RFP (unless such party has advised the Supply Chain Services Department, in writing, of its intent not to respond to the RFP) and shall be deemed to form an integral part of this RFP as if specifically restated herein.

2.7 Submitting the Proposal

(a) **IN ORDER TO BE CONSIDERED BY TORONTO HYDRO, A RESPONDENT MUST SUBMIT ITS PROPOSAL TO THE SUPPLY CHAIN SERVICES DEPARTMENT IN ACCORDANCE WITH THE TERMS IN SCHEDULE A.**

(b) Proposals shall be delivered to the Operation Support Services Department via Global E-Procure. No other forms of Proposals shall be accepted including mailed, couriered or facsimile transmission. Proposals shall be deemed received by the Operation Support Services Department on the date of acceptance, as evidenced by Global E-Procure records. Toronto Hydro will not be responsible for any issues or problems related to the submission of any Proposal by the Submission Deadline. Without limitation, Respondents are solely responsible for ensuring that Proposals are loaded into Global E-Procure to indicate receipt before the time described in SCHEDULE A.

2.8 Modifications or Withdrawal of Proposals before Submission Deadline

(a) Proposals submitted prior to the Submission Deadline may be modified or withdrawn by the Respondent at any time prior to the Submission Deadline, by written notice to the Supply Chain Services Department, delivered via Global E-Procure.

(b) Respondents may not make modifications to their Proposal after the Submission Deadline.

(c) To modify a Proposal prior to the Submission Deadline, the Respondent must withdraw the original Proposal and submit another Proposal to the Supply Chain Services Department, prepared in accordance with the terms of this RFP, bearing the same signature of the authorized representative of the Respondent who executed the original Proposal (or such other authorized representative if the original representative is no longer available, provided a written explanation regarding same is included), clearly marked to show that it
supersedes and invalidates the Proposal(s) previously delivered. No other method of Proposal modification shall be considered.

(d) To withdraw a Proposal prior to the Submission Deadline, the Respondent shall submit to the Supply Chain Services Department a letter to this effect, bearing the same signature of the authorized representative of the Respondent who executed the original Proposal (or such other authorized representative if the original representative is no longer available, provided a written explanation regarding same is included. No other method of Proposal withdrawal shall be considered.

(e) Proposals not submitted by the Submission Deadline will not be considered by Toronto Hydro.

2.9 Ownership of Proposals

Subject to any written agreement to the contrary, all Proposals and other support documentation received by the Supply Chain Services Department from Respondents shall become the property of Toronto Hydro and will not be returned to Respondents. Toronto Hydro will not disclose the Respondent's Proposal to any third party, save and except for disclosure to any Toronto Hydro Representative as may be required to administer this RFP and any resulting Contract or as required by court order or other legal compulsion including, without limitation, disclosure required by the Municipal Freedom of Information and Protection of Privacy Act (Ontario) and requests made by any Governmental Authority.

2.10 Verification of Information

In submitting a Proposal, the Respondent acknowledges and agrees that Toronto Hydro and its Representatives may, in their discretion, independently verify any information provided in a Proposal.

2.11 Clarifications or Supplements to Proposals

Toronto Hydro and its Representatives reserve the right, in their discretion, to seek further information or clarification from any Respondent and Toronto Hydro is entitled to utilize the information or clarifications received in evaluating any Proposal, and may require one or more or all of the Respondents to answer questions or submit supplementary documentation clarifying any matters contained in their Proposals.

2.12 Evaluation of Proposals

(a) Proposals will be opened in private by the Supply Chain Services Department and a Toronto Hydro representative (in Toronto Hydro’s discretion). Toronto Hydro is under no obligation to disclose to any Respondent(s) the contents of the Proposals received or to reveal the Proposal prices.
The successful Respondent(s), if any, will be selected by Toronto Hydro, in its sole discretion, based on Toronto Hydro’s assessment of which Proposal is considered to be the most beneficial to Toronto Hydro based on any number of criteria which Toronto Hydro, in its discretion, considers relevant, including, without limitation, the following (not necessarily in order of importance):

(i) completeness of the Proposal and responsiveness to this RFP;
(ii) qualifications, experience and ability of the Respondent to provide the requested goods/services;
(iii) proposed price;
(iv) other value-added services that may be offered by the Respondent;
(v) reputation of the Respondent and its past relationship with Toronto Hydro or any of its Affiliates;
(vi) the specific evaluation criteria set out in PART B of SCHEDULE B, if any; and
(vii) any other factor that Toronto Hydro, in its discretion, deems relevant.

Toronto Hydro is not obliged to inform the Respondents of the relative weight to be given to any particular evaluation criterion, or to provide reasons to any Respondent with respect to any exercise of Toronto Hydro’s discretion.

Toronto Hydro reserves the right, in its discretion, to negotiate with the Respondent, which, in the opinion of Toronto Hydro, has submitted the most beneficial Proposal, or with any other Respondent or Respondents concurrently. Toronto Hydro and its Representatives shall incur no liability to any other Respondents as a result of such negotiations.

2.13 Selection of Proposals

(a) This RFP does not constitute a call for tenders or a contract to purchase goods or services, and Toronto Hydro is under no obligation or commitment whatsoever to select any Proposal and expressly reserves the right, in its discretion, to reject any or all Proposals without notice or reasons including, without limitation, the lowest priced Proposal. Alternatively, Toronto Hydro reserves the right to select the Proposal that, in its discretion, it deems most advantageous, notwithstanding any custom, usage or agreement in the industry or trade, or any other policy or practice to the contrary.

(b) Toronto Hydro reserves the right, in its discretion, to select any Proposal, irrespective of whether such Proposal is informal, irregular, incomplete, or non-compliant with any of the terms of this RFP, including, without limitation, the terms described in Sections 2.7, 2.19, SCHEDULE A and SCHEDULE B.

(c) Without limiting the generality of the foregoing, Toronto Hydro may, in its discretion and at any time without notice or reasons, and without liability, take any steps it deems appropriate in connection with this RFP process including, without limitation:
(i) modify the terms of or terminate this RFP;
(ii) decline to permit any Respondent to participate in this RFP process;
(iii) terminate discussions or negotiations with any or all Respondents;
(iv) reject any, or part of any, or all Proposals; or
(v) negotiate with any third party regarding matters covered by or related to this RFP, whether such party has been invited to submit a Proposal or not.

(d) If Toronto Hydro does not receive any satisfactory Proposals, which only Toronto Hydro, in its discretion, may determine, or if an insufficient number of Proposals are submitted, or where unforeseen circumstances arise before the Date for Selection of the Successful Respondent(s), it may, in its discretion, either:

(i) amend the scope of work identified in this RFP by issuing post-RFP addenda and inviting one or more of the Respondents to resubmit a Proposal;
(ii) negotiate modifications of any term of this RFP with any Respondent, or Respondents, concurrently;
(iii) include any of the Respondents in post-Submission Deadline negotiations;
(iv) reject all Proposals and re-issue the RFP to some or all of the Respondents and any third parties selected by Toronto Hydro, in its absolute discretion; or
(v) cancel this RFP.

(e) Neither Toronto Hydro nor any of its Representatives shall incur any obligation or liability to any Respondent in the exercise of any of the rights noted above.

2.14 Confidentiality

(a) This RFP, and all information and data disclosed by Toronto Hydro in relation thereto, including without limitation all information related to Toronto Hydro's business operations, processes or technology, whether marked as confidential or not, constitutes “Confidential Information” which is, and will remain, the property of Toronto Hydro, and is not to be copied or distributed without the prior written approval of Toronto Hydro.

(b) Notwithstanding the foregoing, Confidential Information does not include any information or data which:

(i) is or becomes publicly known through no breach of the terms or conditions of this RFP; or
(ii) is independently developed by a third party without reference to Confidential Information and without breach of the terms or conditions of this RFP.
(c) The Respondent agrees to maintain the confidentiality of the Confidential Information, and further agrees not to use or duplicate such Confidential Information for any purpose other than responding to this RFP, and will not, without the prior written consent of Toronto Hydro, disclose or make any Confidential Information available to any third party.

(d) Notwithstanding any obligations of confidentiality herein, the Respondent may disclose Confidential Information where required to do so by court order or other legal compulsion, provided the Respondent gives Toronto Hydro prior notice, as permitted by law, of the compulsory disclosure.

(e) Upon request, the Respondent shall forthwith return to the Supply Chain Services Department all Confidential Information, including any copies thereof; and, where such Confidential Information is in electronic form, destroy such Confidential Information and provide the Supply Chain Services Department with a certificate from a senior officer of the Respondent attesting to such destruction.

(f) The terms of this Section 2.15 shall survive any termination or expiry of this RFP for the longer of five (5) years after (i) the Submission Deadline; and (ii) the termination or expiry of this RFP.

2.15 No Representations or Warranties

(a) Nothing in this RFP is intended to relieve Respondents of their responsibility to form their own opinions and conclusions in respect of the matters addressed in this RFP and to satisfy themselves independently regarding the accuracy and completeness of the information provided and the assumptions made in this RFP. Toronto Hydro and its Representatives make no representations or warranties, either express or implied, in fact or in law, with respect to the accuracy or completeness of the information provided in this RFP.

(b) Without limiting the generality of the foregoing, Toronto Hydro and its Representatives shall not be liable for any claim, action, cost, loss, damage or liability whatsoever arising from or related to any information or advice or any errors or omissions that may be contained in this RFP or any data, materials, or documents disclosed or provided to the Respondent pursuant to this RFP or otherwise. The only representations and warranties made by Toronto Hydro or its Representatives, if any, will be those contained in the Contract.

2.16 No Damages

(a) All costs, expenses, losses, damages and liabilities which may be incurred by the Respondents as a result of or arising out of the submission, acceptance or rejection of their Proposals, including the cost of preparing and submitting a Proposal, shall be borne entirely by the Respondents. Toronto Hydro and its Representatives shall not be liable for any costs and expenses incurred by the Respondents, or to reimburse the Respondents in any manner whatsoever or under any circumstances, including, without limitation, in the event of
rejection of all Proposals, rejection of the Respondent's Proposal, selection of another Respondent's Proposal, waiver or non-waiver of a non-compliance by any Respondent, including the matters described in Sections 2.7, 2.19, SCHEDULE A and SCHEDULE B, issuance of a post-RFP addenda, a decision not to include any Respondent in post-Submission Deadline negotiations, or cancellation of this RFP.

(b) Without limiting the generality of the foregoing, Toronto Hydro and its Representatives shall not be liable, in contract, tort, restitution or any other legal theory, to a Respondent for any claim, action, costs, losses, damages or liability whatsoever arising from any act or omission by Toronto Hydro or its Representatives, including the rejection of any or all of the Proposals, the consideration or evaluation of any or all of the Proposals, negotiations in respect to the Proposals, the selection of a Respondent, the decision to issue post-RFP addenda to some or all of the Respondents, the decision not to include a Respondent in post-Submission Deadline negotiations, the decision to waive or not to waive a non-compliance by a Respondent, including in respect of the matters described in Sections 2.7, 2.19, SCHEDULE A and SCHEDULE B, or for any information or advice or any errors or omissions that may be contained in this RFP or any data, materials, or documents disclosed or provided to a Respondent pursuant to this RFP or otherwise.

2.17 No Collusion

Each Respondent's Proposal shall be prepared without any connection, knowledge, comparison of information, or arrangement with any other Respondent (or any Representative thereof) and each Respondent shall be responsible to ensure that its participation in this RFP process is conducted fairly and without collusion or fraud.

2.18 Conflicts of Interest

The Respondent is required to disclose in its Proposal and on an ongoing basis thereafter any conflict of interest, real or perceived, that exists now or may exist in the future, with respect to this RFP, any resulting Contract, or in relation to Toronto Hydro or its Representatives.

2.19 Assignment

The Respondent may not assign the right to issue a Proposal in response to this RFP to any third party, including any of the Respondent's Affiliates, without Toronto Hydro's prior written consent.

2.20 Governing Law

This RFP, all Proposals submitted in response thereto, and any resulting Contract, shall be governed by the laws in force in the Province of Ontario and the laws of Canada applicable therein.
3. **PROPOSAL REQUIREMENTS**

All Proposals shall contain the information set out in PART A of SCHEDULE B.

4. **GOODS/SERVICES REQUIRED**

Toronto Hydro is seeking Proposals from Respondents for the goods and/or services described in PART B of SCHEDULE B, including any Appendices thereto. Respondents shall indicate in their Proposals whether they can meet the requirements and specifications listed in Part B of SCHEDULE B, including any Appendices thereto.

5. **CONTRACT NEGOTIATIONS**

5.1 **Contract Terms and Conditions**

If selected by Toronto Hydro, the successful Respondent(s) shall enter into a Contract with Toronto Hydro which shall be in a form satisfactory to Toronto Hydro, and shall include, without limitation, reference to the specifications and requirements in PART B of SCHEDULE B, the Standard Terms and Conditions of SCHEDULE C and any Additional Terms and Conditions as may be set out in SCHEDULE C-2, subject to any negotiated amendments or modifications thereto acceptable to Toronto Hydro in its discretion.

5.2 **Contract Negotiations**

(a) Toronto Hydro anticipates that it will enter into negotiations with the successful Respondent(s), if any, with a view to finalizing and, where applicable, signing the Contract by no later than the Date for Execution of the Contract specified in SCHEDULE A.

(b) If the terms of the Contract cannot be finalized by the Date for Execution of the Contract specified in SCHEDULE A, or such other period to be determined solely by Toronto Hydro, then Toronto Hydro may, in its discretion, terminate negotiations with such Respondent(s), reject the Respondent's Proposal, issue a post-RFP addenda, issue a new RFP or negotiate a Contract with another Respondent or any other party.

(c) Upon agreement of the Contract terms, the Respondent agrees to return the signed Contract, where applicable, together with the specified certificate of insurance, surety bonds and Workplace Safety and Insurance Board certificates, as may be applicable, to Toronto Hydro within one (1) week from the date of Toronto Hydro’s delivery of said Contract.
5.3 **No Liability**

No Respondent shall have any rights against Toronto Hydro or its Representatives arising from the selection or non-selection of any Respondent(s) including the selection of a Respondent with a Proposal that is non-compliant with the terms of this RFP. Any and all commitments, representations, warranties or obligations of Toronto Hydro or its Representatives shall be limited to those specifically stated in an executed Contract between Toronto Hydro and a successful Respondent(s), if any.
SCHEDULE A

RFP PROCEDURES

(a) QUESTIONS/COMMUNICATIONS WITH TORONTO HYDRO

All questions or communications regarding this RFP are to be addressed solely to:

Attention: Rajesh Yata, Supply Chain Specialist
Supply Chain Services Department
Reference: RFP No. 16P-126
Toronto Hydro-Electric System Limited
Ground floor, 601 Milner Avenue
Toronto, Ontario M1B 2K4
E-mail: ryata@torontohydro.com
Facsimile: 416-542-2663
Telephone: 416-542-3191

(b) RFP SCHEDULE

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue of RFP</td>
<td>December 30, 2016</td>
</tr>
<tr>
<td>Deadline for Submission of Questions</td>
<td>January 13, 2017</td>
</tr>
<tr>
<td>Submission Deadline</td>
<td>January 30, 2017</td>
</tr>
<tr>
<td>Shortlisted Vendor Presentations</td>
<td>Week of February 06, 2017</td>
</tr>
<tr>
<td>Date for Selection of Successful Respondent(s)</td>
<td>February 28, 2017</td>
</tr>
<tr>
<td>Date for Execution of the Contract</td>
<td>March 30, 2017</td>
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(c) SUBMISSION OF PROPOSALS

A Respondent shall submit Proposal via Global E-Procurement, signed by an authorized individual in accordance with Section (c) of PART A of SCHEDULE B the RFP by no later than 1:59:59 p.m. EST on the Submission Deadline.
SCHEDULE B

PART A -- PROPOSAL REQUIREMENTS

All Proposals shall contain the following information, and be presented in the following order:

(a) **Title Page**

The cover page of all Proposals should be in the form of SCHEDULE D.

(b) **Table of Contents**

All Proposals in excess of five (5) pages should contain a table of contents showing all required sections and all submitted appendices, if any.

(c) **Respondent's Certificate**

Respondents shall complete, sign, and attach a copy of the Respondent's Certificate in SCHEDULE E to their Proposal. The Respondent's Certificate must be dated, signed by an individual authorized to bind the Respondent pursuant to the terms and conditions of this RFP.

(d) **Letter of Introduction and Summary of Proposal**

The next section of each Proposal shall consist of a letter, no more than two (2) pages in length, that introduces the Respondent and highlights the key features of the Respondent's Proposal.

(e) **Information Regarding Respondent**

The next section of the Proposal shall provide details regarding the Respondent, including without limitation, and as may be applicable:

(i) a description of the Respondent's corporate structure, including an organizational chart identifying the Respondent's parent, subsidiaries or other Affiliated corporations, partnerships or organizations;

(ii) if the Proposal is submitted by a partnership, the correct name, firm and style of such partnership must be given, together with the names of all partners;

(iii) a current copy of the Respondent's current credit report and name of rating agency (required);

(iv) a description of the strength and size of the Respondent's business in the Ontario market, with particular emphasis on Toronto-based operations (such information may include, for example, annual dollar sales, or market share percentage);

(v) a copy of all regulatory licences, approvals and authorizations held by Respondent in Ontario that may be relevant to the Contract; and
(vi) any further information relating to the Respondent as may be required in PART B OF SCHEDULE B.

(f) **Price Offer**

This section of the Proposal contains the Respondent's detailed itemized pricing information for all goods or services as required in PART B OF SCHEDULE B.

All pricing shall be expressed in Canadian currency.

The pricing information shall also include:

(i) a description of any conditions or qualifications relevant to the Respondent's ability to contract with Toronto Hydro at the quoted prices or generally;

(ii) all prices shall indicate any applicable taxes (including Harmonized Sales Tax), duties or charges separately;

(iii) any alternative pricing offer(s), as may be available in the Respondent's discretion; and

(iv) any further details or description of the Respondent's proposed price offer which the Respondent deems relevant or important to disclose, including details regarding how volume adjustments would be managed, and what impact such adjustments would have on the price, if any, should Toronto Hydro wish to reduce or increase volumes during the Contract term.

Any alternative price offers may be considered by Toronto Hydro, in its sole discretion.

(g) **Additional Goods/Services**

The Respondent shall provide a description of any additional or related goods or services that it can offer to Toronto Hydro, if any, and clearly specify any and all additional costs related thereto.

(h) **Additional Information**

This section shall provide any additional information that the Respondent estimates, in its discretion, will assist Toronto Hydro in reviewing and assessing the Proposal.

(i) **Sustainability**

Please see Questionnaire Tab in Global E-Procure Tool.
PART B – GOODS/SERVICES REQUIRED

(a) Introduction

Toronto Hydro-Electric System Limited ("THESL") has adopted a risk-based approach for determining the optimal timing to intervene on individual assets and to support the creation of business cases for capital and operational work. These risk costs include both the direct tangible costs to the utility, as well as the customer interruption costs, which to date have been based upon research conducted through past studies. As part of a commitment to continuous improvement, THESL would like to explore enhancement opportunities for these customer interruption costs, using new sets of data parameters including those from within the City of Toronto.

(b) Proposal

The successful Respondent shall perform a survey-based interruption cost study in order to provide estimates of interruption costs by Toronto Hydro’s customer classes, which can be generalized as:

- Residential;
- Small and Medium Commercial & Industrial ("C&I"); and
- Large C&I

The study will survey customers across the service territory to determine class specific values which can thereby be aggregated to determine system-wide values. To ensure THESL’s diverse customer base is reflected in the study, customers with electric vehicles and renewable energy sources such as the Feed-in-Tariff (FIT) and micro-FIT generation will also be part of the survey respondents. It is also important to capture residential customers who work or operate their businesses from home. Finally, the successful Respondent shall also determine interruption costs at a neighbourhood level. For further information, please refer to:

http://www.toronto.ca/demographics/profiles_map_and_index.htm

The study will also focus on customer satisfaction and preferences related to safety and environmental improvements (such as SF6 gases, oil spills, promotion of energy efficiency and support for renewable energy sources). It shall also contain “packages” for each customer class which have specific descriptions of reliability. The survey respondent will be asked to rank the packages in the order that best meets their reliability requirements.

The successful Respondent will be required to comply with Toronto Hydro’s Privacy Terms and Conditions attached as Appendix A to Schedule C-2 of this RFP.

Survey Approach

The successful Respondent will outline the methodology they intend to use for this survey. An example of such methodology could be both direct (such as direct-worth, willing to pay or accept) and indirect methods (such as preparatory action methods). In addition, the successful Respondent should also discuss the following:
• How the successful Respondent intends to perform the survey (direct mail, site visits, emails or a combination) for each customer class
• Methods to increase the response rates for each customer class;
• Steps to identify customers (survey respondents) of all demographics, including residential customers who operate their business from home;
• Discussion on ideal sample size to ensure acceptable confidence levels for each customer class;
• Samples of “packages” for each customer class with specific descriptions of reliability;
• Solicit feedback from customers on areas where THESL’s service can be improved;
• How the successful Respondent intends to include and quantify costs of customers that have renewables (micro-FIT and FIT) and electric vehicles;
• Sample questionnaires for each customer class reflecting the diverse customer base in each class (especially residential customers). Please include examples of both “direct-worth” and “willingness to pay or accept” questions.

(c) Information Regarding Respondent

i. Project Team

Respondents shall identify the project lead and all project team members. The Proposal shall include a resume for each of these individuals as it relates to this project. The Proposal shall clearly indicate the involvement team members will have in various areas of the study.

ii. List of Related Projects

Respondents shall submit a list of survey-based interruption cost studies performed that are similar to this request. For each study on the list, please provide a brief description of the work conducted, the name of the utility and a contact at that utility.

(d) Deliverables Required

Reports shall be provided to THESL in both a printed format and electronic format as a Word (.docx) document and shall be appended to provide the necessary supporting documentation. The successful Respondent may also be required to provide written and oral support to THESL as part of regulatory proceedings at the Ontario Energy Board (“OEB”) in respect of the consulting services performed for THESL. For this work, the successful Respondent should quote an hourly rate. The successful Respondent may also be required to agree to be subject to Rule 13A of the OEB’s Rules of Practice and Procedure, which requires the successful Respondent to assist the OEB by giving fair and objective evidence. The successful Respondent would be required to sign
a declaration that they are aware of and accepts the responsibilities that may be imposed by Rule 13A. A copy of the Rule 13A is attached for reference.

**Required Work**

The successful Respondent shall provide a report that includes:

- Customer Interruption Costs for each customer class based on “Event” and “Duration” cost components;
- Event costs should be provided in both “$/kW”, “$/kVA”, and “$/customer” for each customer class;
- Duration Cost should be provided in both “$/kWh”, “$/kVAh”, and “$/customer-hour” for each customer class;
- Customer expectations for service reliability (i.e. frequency and duration of interruptions customers consider acceptable, power quality, momentary outages, planned or unplanned outages) by customer class;
- Customer perceptions of service reliability by customer class;
- Result breakdown by industry, neighbourhoods, load consumption, and time intervals and other segmentations as appropriate;
- Descriptions of the survey methodologies and analytical techniques;
- Copies of the survey instruments;
- Packages include specific values of reliability tied to costs for each customer class who ranked them;
- Impact of renewables and electric vehicles in both the event and duration costs; and
- Separate result breakdowns based on indirect and direct methods (direct-worth and willing to pay or accept).

**Data**

Separate from the report, THESL would require the comprehensive digital version of the raw data from the survey broken down by customer class to be submitted in MS-Excel format. All the reports and data submitted to THESL will become the intellectual property of THESL.

**Exceptions**

Respondents may include a schedule with ‘Exceptions to the Specific and General Conditions’ (if any). In the absence of such an explicit list, it shall be understood and agreed that the Respondent’s Proposal is based on strict conformance to these requirements and intent of the specifications in all respects. If ambiguities or options are noted in the Proposal, it is the Respondent’s responsibility to clearly state the interpretation of such a requirement and how the bid price has factored that option or ambiguity. If exceptions are taken, they will be cleared in writing before
the award is made. Any description or clarification stated in the Proposal that deviates from the specifications described herein shall not be considered as an exception unless listed in accordance with this paragraph.

**Work Schedule**

As part of the Proposal, the Respondent shall provide a schedule with the Proposal indicating, as a minimum, the following:

- Major milestones;
- Significant project tasks with planned start and end dates; and
- Percentage each task represents of the total effort.

The work schedule must align to THESL’s deadlines provided in (e) below.

**(e) Pricing Requirements/Payment Terms**

**Fixed Pricing**

Respondents must complete the Schedule G, Price Form attached hereto as an electronic file. The price shall be submitted in Canadian dollars ($CDN) including all applicable taxes except for value added taxes such as HST.

Proposals shall include a *fixed-cost price* for the required work. For the purpose of evaluating Proposals, the fixed-cost price shall assume the following sample sizes for each customer class:

- Residential – 1,000
- Small and Medium C&I ( < 1 MW) – 800
- Large C&I ( > 1 MW) – 100*

*For Large C&I customers, the successful Respondent will be working with THESL’s Representatives to engage with these customers.*

**Unit Pricing**

Because Respondents may consider other sample sizes more appropriate, the Proposal shall include information that shows how sample sizes, different from above, decrease or increase the cost of the required work (e.g., a per unit sample cost by customer class). Respondents are also asked to provide separate cost items if different methodologies are proposed.

The successful Respondent will work together with THESL to finalize sample sizes and resulting cost based on the information presented in the Proposal.
**Hourly Rate**
Respondents shall also quote an hourly rate for additional work and/or consulting services (including involvement in regulatory proceedings with the OEB).

**Payment Terms**

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Amount (% of total contract value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identifying customers and mailing out surveys</td>
<td>35%</td>
</tr>
<tr>
<td>2. Draft Report (consisting of survey results and analysis)</td>
<td>35%</td>
</tr>
<tr>
<td>3. Substantial completion and final report submission</td>
<td>30%</td>
</tr>
</tbody>
</table>

*Table 1: Milestone Payment Table*

(f) **Subcontractors**

Use of subcontractors is not allowed for this project.

(g) **Timelines**

**Project Timelines**

The basic work tasks for the required work include:
- Stakeholder meeting and project plan development
- Study planning and design
- Sample design, survey procedures – Residential
- Sample design and survey procedures – Small and Medium C&I
- Sample design and survey procedures – Large C&I
- Identifying survey customers and neighbourhoods
- Survey execution
- Data analysis
- Substantial completion of deliverables
- Final report/data submission

Below is a tentative start and end dates for this project. Respondent’s Proposals shall include a schedule that combines the tasks listed above with the project timeframe identified below.

- Project start date will coincide with the *Date for Execution of the Contract* as prescribed in SCHEDULE A.
- Draft Report due: September 15th, 2017
- Final report due: November 24th, 2017

(h) **Toronto Hydro’s Responsibilities**
THESL will collaborate with the successful Respondent in customer identification processes by providing a certain number of customer addresses, including FIT, micro-FIT, and EV customers. These customer lists will provide a representative sample of THESL’s existing customer base.

(i) **Environmental Attributes of Good or Service**

Please see Questionnaire Tab in Global e-Procure.
SCHEDULE C

STANDARD TERMS AND CONDITIONS

1. Standard Terms and Conditions

The Vendor’s commencement of performance of the terms of the Contract, including delivery of all or part of the goods/services, shall be deemed to conclusively evidence the Vendor’s agreement and acceptance of these Standard Terms and Conditions and the Additional Terms and Conditions in SCHEDULE C-2, if any. Toronto Hydro’s acceptance of the Vendor’s goods or services shall not constitute acceptance of any additional or different terms in the Vendor’s invoice or other documentation. No modification or amendment to these Standard Terms and Conditions shall be binding on Toronto Hydro unless agreed to in writing.

2. Term

Subject to any termination rights in the Contract, the term of the Contract shall be as set out in the Contract.

3. Price and Payment

a) The price shall be as specified in the Contract and, except as otherwise provided, shall be in Canadian dollars DDP Toronto Hydro’s location (INCOTERMS 2010), and shall represent the total cost to Toronto Hydro, excluding any value added taxes (including Harmonized Sales Tax) but including all other applicable taxes, duties, packaging, handling and delivery costs. Toronto Hydro shall withhold any applicable non-resident withholding taxes from any amount owing under the Contract and remit such taxes to the appropriate federal taxing authority. If no price is stipulated in the Contract, the price must not exceed the last previous quotation made by the Vendor to Toronto Hydro for the same goods or services.

b) Unless otherwise provided in the Contract, the Vendor shall invoice Toronto Hydro after final inspection and acceptance by Toronto Hydro of the goods and services supplied and subject to receipt of all documents required by the Contract. **Invoices must be sent electronically to: TH-AP@opiscan.com and ap@torontohydro.com.** Subject to approval of the invoice by Toronto Hydro, Toronto Hydro shall make payment to the Vendor via electronic funds transfer not later than thirty (30) days following receipt of an acceptable invoice.
4. Delivery of Goods/Services

a) All goods and services shall be delivered and/or performed in accordance with the terms, specifications and schedules specified in the Contract. The Vendor shall immediately notify Toronto Hydro, in writing, of any circumstances known or suspected that may cause delay in the delivery of goods/services. Unless otherwise agreed in writing, Toronto Hydro will not accept deliveries in excess of those specified in the Contract and such deliveries shall be entirely at the Vendor’s risk and may be returned by Toronto Hydro to the Vendor at the Vendor’s sole cost and expense.

b) In the event of any question, dispute, disagreement or difference of opinion between Toronto Hydro and the Vendor relating to the quality or acceptability or rate of progress of any goods or services or relating to the interpretation of the specifications in the Contract or the performance of the Contract, the opinion of Toronto Hydro or its authorized Representative shall govern and be binding on the parties hereto.

5. Subcontractors

The Vendor may only subcontract any of the services or the manufacture or delivery of any goods under the Contract with the prior written consent of Toronto Hydro. If subcontracting is permitted, the Vendor shall enter into agreements with such subcontractors to require them to perform the services and manufacture or deliver the goods in accordance with all Applicable Laws and the terms of the Contract and the Vendor shall be liable for any acts or omissions of such subcontractors as if such acts or omissions were those of persons directly employed by the Vendor. The Vendor agrees to incorporate the terms of the Contract into all subcontract agreements with its subcontractors. Any subcontract shall not relieve the Vendor from any of its obligations or liabilities under the Contract.

6. Risk of Loss

All goods shall be safely and securely packed for shipment. Title to and risk in the goods shall pass to Toronto Hydro on delivery. All delivery costs, including insurance, are for the account of the Vendor.

7. Invoice Requirements

The Vendor must render two (2) copies of invoices with the bill of lading attached, on the same day that shipment is made.

The Vendor shall submit invoices to Toronto Hydro in accordance with the payment terms as set out in SCHEDULE B containing:

(i) a detailed description of the Services performed during the invoice period;
(ii) the dates and the amount of time spent by the Vendor for the provision of the Services;

(iii) the hourly rates;

(iv) the total HST applicable to the Services during the invoice period, as well as the Vendor’s HST registration number; and

(v) a detailed description of any applicable disbursements incurred around the invoice period, supported by documentation in a form acceptable to Toronto Hydro.

8. **Time of the Essence**

Time is of the essence in the Contract. The Vendor shall deliver all goods and/or perform all services in accordance with the dates and times for performance and delivery specified in the Contract and Toronto Hydro shall have the right to take possession of and use any completed or partially completed portions notwithstanding any provisions expressed or implied to the contrary.

9. **Force Majeure**

a) As used herein, “Force Majeure” means events beyond the reasonable control of a party applying reasonable diligence and foresight given the nature of the goods/services being provided under the Contract, including, as applicable, any Acts of God and the public enemy, the elements; fire; accidents; vandalism; sabotage; power failure; strikes, lockouts or any other industrial, civil or public disturbances; any laws, orders, rules, regulations, acts or restraints of any government or governmental body or authority, civil or military, including the orders and judgments of courts and any other similar causes or acts.

b) If, by reason of Force Majeure, either party hereto (the “Frustrated Party”) is delayed or unable, in whole or in part, to perform or comply with any obligation or condition of this Contract, then it will be relieved of liability and will suffer no prejudice for failing to perform or comply or for delaying such performance or compliance during the continuance and to the extent of the inability so caused from and after the happening of the event of Force Majeure, provided that it gives to the other party prompt notice of such inability, reasonably full particulars of the cause thereof and the expected cessation. If notice is not promptly given, then the Frustrated Party will only be relieved from performance or compliance from and after the giving of such notice. The Frustrated Party will use its best efforts to remedy the situation and remove, so far as possible with reasonable dispatch, the cause of its inability to perform or comply, provided, however, that settlement of strikes, lockouts and other industrial disputes shall be within the discretion of the Frustrated Party. The Frustrated Party will give prompt notice of the cessation of Force Majeure. If at any time the Vendor cannot deliver any of the goods or services required to be provided pursuant to the Contract due to Force Majeure, Toronto Hydro may engage any other party to provide such goods or services which the Vendor cannot provide. The benefit of this provision shall only survive for thirty (30) days from the commencement of an event of
Force Majeure. A requirement to disclose Confidential Information other than under Canadian law pursuant to the terms of the Contract shall not be an event of Force Majeure. A failure by a sub-contractor to perform shall not be an event of Force Majeure for a Frustrated Party unless such sub-contractor is itself suffering from an event of Force Majeure and the provisos set forth above are followed.

10. **Representations and Warranties**

The Vendor represents and warrants to Toronto Hydro that:

a) it has the corporate power and authority to enter into the Contract and to perform its obligations thereunder, and that the Contract constitutes a legal, valid, and binding obligation of the Vendor, enforceable against the Vendor in accordance with its terms;

b) the Vendor, after conducting due diligence, is not aware of any actions, suits or other legal proceedings which may affect its ability to perform the Contract;

c) it is the absolute beneficial owner of the goods, with good and marketable title, free and clear of all liens, charges, encumbrances or rights of others and is exclusively entitled to possess and dispose of the same;

d) the services shall be performed in a professional, diligent and competent manner and shall meet or exceed those standards generally observed by reputable and competent members of the same industry providing similar services;

e) it is an expert, trained, equipped and capable in providing the services and shall only use reliable, qualified and competent persons, as that term is defined in the Occupational Health and Safety Act (Ontario) (the “OHSA”), to perform the services;

f) it is in compliance with and has paid, and will continue to pay, all assessments and other amounts owing pursuant to the Workplace Safety and Insurance Act, (1997) (Ontario); and

g) it is satisfied with the conditions under which the Goods will operate, and shall assume full responsibility for understanding the conditions of supply, operation, and service.

11. **Warranty**

All Goods and/or Services shall be in compliance with all Applicable Laws and will conform to the specifications, drawings, samples, symbols or other descriptions as specified in SCHEDULE A hereto and will be fit an sufficient for their intended purpose, merchantable and free from defects in material and workmanship. This warranty is in addition to all other warranties specified in the Contract or implied by law and shall survive acceptance and payment.
12. **Inspection**

All goods delivered and services performed will be subject to final inspection and approval by Toronto Hydro after delivery or performance, notwithstanding any prior payment. In the event that goods are delivered or services are performed which are not in conformity with the terms and conditions and specifications of the Contract, Toronto Hydro may, at its option:

a) reject the goods and services and require the Vendor to immediately re-deliver the goods and re-perform the services;

b) negotiate with the Vendor an agreeable reduction in the price of the delivered, non-conforming goods and services;

c) rework, or cause to be reworked, the delivered, non-conforming goods and services, at the Vendor’s expense, which expense shall constitute a proper set-off by Toronto Hydro against amounts otherwise due to the Vendor under the Contract; or

d) reject the Goods and/or Services and require a repayment of applicable amounts for such deliverables.

13. **Termination**

a) Toronto Hydro may, for its convenience and at its sole option, terminate the Contract by providing at least sixty (60) days prior written notice of such termination. Upon issuance of such notice, the Vendor shall stop delivery of the goods and performance of the services under the Contract, except as may be necessary to carry out such termination and take any other action which Toronto Hydro may reasonably direct. Upon a termination for convenience, Toronto Hydro shall pay for such goods and services requested and accepted by Toronto Hydro up until the effective date of such termination. Toronto Hydro shall not be liable to the Vendor for any other costs or damages whatsoever arising from such termination, including, without limitation, any indirect, consequential or special damages such as a loss of profit or loss of opportunity.

b) If the Vendor fails to fulfil any covenant or material obligation under the Contract, including, without limitation, the failure to meet the delivery schedule or any specification contained therein, or breaches any representation or warranty contained therein, then Toronto Hydro may, without prejudice to any other right or remedy Toronto Hydro may have, notify the Vendor in writing that the Vendor is in default of its contractual obligations and instruct the Vendor to correct the default within five (5) Business Days immediately following the receipt of such notice. If the Vendor fails to correct the default in the time specified, then, without prejudice to any other right or remedy Toronto Hydro may have, Toronto Hydro may either correct such default and deduct the cost thereof from any payment then or thereafter due to the Vendor and/or terminate the Contract.

c) If bankruptcy or insolvency proceedings are instituted by or against the Vendor or the Vendor is adjudicated a bankrupt, becomes insolvent, makes an assignment for the benefit
of creditors or proposes or makes arrangements for the liquidation of its debts, or a receiver or receiver and manager is appointed with respect to all or part of the assets of the Vendor, Toronto Hydro may, without prejudice to any other rights or remedies it may have, immediately terminate the Contract.

d)  The termination of the Contract shall not affect any rights or obligations which may have accrued prior to such termination or any other right which the terminating party may have arising out of either the termination or the event giving rise to the termination.

14.  Liability and Indemnification

The Vendor shall be liable for and shall indemnify and hold harmless Toronto Hydro and its Representatives from all claims, demands, actions, penalties, damages, losses, judgments and settlements, liabilities, costs, expenses, including legal fees and other related costs and expenses arising out of, related to, or incident to, the Vendor or any of its Representatives’ supply of the goods or performance of the services under the Contract, including, without limitation:

a) any breach, violation or non-performance by the Vendor or any of its Representatives of any terms, conditions, warranties, obligations or covenants contained in the Contract;

b) any breach or violation by the Vendor or any of its Representatives of any Applicable Laws; and

c) any actions, omissions, negligence or wilful misconduct of the Vendor or any of its Representatives.

15.  Health and Safety

a) The Vendor shall be responsible for:

(v) managing the health and safety of its own personnel and other Representatives;

(vi) ensuring compliance with all Applicable Laws related to health and safety, including without limitation the OHSA; and

(vii) ensuring that its personnel and other Representatives are aware of any safety hazards involved in working in or around Toronto Hydro’s facilities and all Applicable Laws with respect thereto.

b) Neither Toronto Hydro, nor its Representatives, shall be liable for any loss, damages or claims arising directly or indirectly from the Vendor’s work in or around Toronto Hydro’s facilities, and the Vendor hereby waives any claims to which it may become entitled for such loss or damage and releases Toronto Hydro and its Representatives from any and all such claims.
16. Insurance

a) Unless otherwise specified in the Contract, the Vendor shall, during the term of the Contract, and at its own expense, maintain and keep in full force and effect:

(i) commercial general liability insurance on an occurrence basis having a minimum inclusive coverage limit, including personal injury and property damage, of not less than five million dollars ($5,000,000.00) per occurrence, which shall be extended to cover contractual liability, products completed, operations liability, owners/contractors protective liability and must also contain a cross liability clause and a severability of interest clause, and must name Toronto Hydro and its Affiliates as additional insureds; and

(ii) automobile liability insurance on all owned and non-owned vehicles used in connection with the Contract and such insurance coverage shall have a limit of not less than two million dollars ($2,000,000.00) per occurrence, in respect of bodily injury (including passenger hazard) and property damage inclusive of any one accident and mandatory accident benefits.

b) All insurance coverages and limits required to be maintained by the Vendor shall be primary to any insurance maintained by Toronto Hydro, which shall be excess and non-contributory. Prior to the commencement of the delivery of the goods or performance of the services, the Vendor shall deliver to Toronto Hydro a certificate of insurance which evidences the Vendor’s compliance with this Section, including the provision of a thirty (30) day prior written notice of cancellation, non-renewal or adverse material change, to Toronto Hydro. The Vendor agrees that the insurance described herein does in no way limit the Vendor’s liability pursuant to the indemnity provisions of the Contract.

c) A waiver of subrogation shall be provided by the insurer(s) to Toronto Hydro.

17. Intellectual Property Protection

The Vendor expressly warrants that the manufacture, delivery, sale or use of the Vendor’s goods or services will not infringe any Canadian or foreign patents, trademarks, copyrights, industrial design or other intellectual property rights and the Vendor shall save Toronto Hydro and its Representatives harmless from all claims, judgments and decrees that may be entered against Toronto Hydro or its Representatives and against all damage, liability, costs and expenses (including legal fees and other attendant costs and expenses) Toronto Hydro or its Representatives incurs by reason of any infringement or claim thereof.

18. Confidential Information

The parties agree and acknowledge that, subject to Applicable Laws or court order:

a) each party (the "Receiving Party") shall maintain in strict confidence the terms of the Contract and any and all proprietary and confidential information about the business,
operations or customers of the other party or any of their Affiliates, which it acquires in any form from the other party (the "Disclosing Party") by virtue of the Contract ("Confidential Information") and will not disclose to any third party or make use of such Confidential Information for itself or any third party without the prior written consent of the Disclosing Party;

b) the Receiving Party may disclose such Confidential Information to any of the Representatives of the Receiving Party or any of its Affiliates who agree to be bound by the obligations of confidentiality herein and who have a reasonable need to know such Confidential Information in the course of their duties for the Receiving Party but only for the purposes of the Receiving Party exercising its rights and obligations under the Contract;

c) Toronto Hydro is subject to MFIPPA and is governed by governmental authorities such as the OPA and the OEB and shall have the right to disclose Confidential Information in accordance with the provisions of MFIPPA or as required by the OPA or the OEB;

d) a party shall be entitled to all remedies available at law or in equity to enforce, or seek relief in connection with any breach of obligations pursuant to this section;

e) the Receiving Party shall be responsible for any breach of the Contract by it and its Representatives and by any other person to whom it discloses any Confidential Information. The Parties agree that the Disclosing Party would be irreparably injured by a breach of the Contract by the Receiving Party, or by any person to whom it discloses any Confidential Information, and that monetary damages would not be a sufficient remedy. Therefore, in such event, the Disclosing Party shall be entitled to all available equitable relief, including injunctive relief without proof of actual damages, as well as specific performance. Such remedies shall not be deemed to be exclusive remedies for a breach of the Contract but shall be in addition to all other remedies available at law or equity; and

f) upon termination of this Agreement, or upon ten (10) days prior written notice from the Disclosing Party requesting return of any or all Confidential Information, the Receiving Party shall forthwith return to the Disclosing Party all Confidential Information, including without limitation all copies of any form of the Confidential Information, the Receiving Party has received and, at the option of the Disclosing Party, deliver to the Disclosing Party, or destroy or have destroyed, any copies or other reproductions of the Confidential Information together with all notes, analyses, reports and other written material whatsoever prepared by, or on behalf of, the Receiving Party, from, or in respect of, the Confidential Information; provided that the Receiving Party shall be entitled to keep, subject always to all the provisions of the Contract, one copy of such notes, analyses, reports or other written material prepared by, or on behalf of, the Receiving Party for its records. The Receiving Party shall provide to the Disclosing Party, upon request, a certificate of an officer of the Receiving Party certifying such destruction; and

g) notwithstanding section 17(a), in the event that the Receiving Party believes it is required by law to disclose, or is requested by a Governmental Authority to disclose, any Confidential Information to a Governmental Authority, the Receiving Party may so disclose; provided that it shall, to the extent permitted by law, first inform the Disclosing Party.
Party of the request or requirement for disclosure to allow an opportunity for the Disclosing Party to apply for an order to prohibit or restrict such disclosure.

19. Assignment

Save and except for Toronto Hydro’s right to assign the Contract to any of its Affiliates, neither party may assign the Contract or any of its rights or obligations thereunder, in whole or in part, without the prior written consent of the other party, which consent may not be unreasonably withheld.

20. Relationship of the Parties

Nothing contained in the Contract shall be construed to constitute either party as the partner, employee or agent of, or joint venturer with the other party, nor shall either party have any authority to bind the other in any respect, it being intended that each party shall remain an independent contractor of the other. The Vendor is responsible for all deductions and remittances required by law in relation to its employees, including those required for Canada employment insurance, workers’ compensation and income tax.

21. Severability

In the event that any of the covenants herein shall be held unenforceable or declared invalid for any reason whatsoever, to the extent permitted by law, such unenforceability or invalidity shall not affect the enforceability or validity of the remaining provisions of the Contract and such unenforceable or invalid portion shall be severable from the remainder of the Contract.

22. No Waiver

A waiver of any provisions of the Contract shall not constitute either a waiver of any other provisions or a continuing waiver, unless otherwise expressly indicated in writing.

23. Enurement

The Contract and everything contained therein shall enure to the benefit of, and be binding upon, the parties thereto and their respective successors and permitted assigns.

24. Notice

All notices, requests, claims, demands and other communications under the Contract shall be in writing and shall be deemed (in the absence of evidence of prior receipt) to have been validly and effectively given on the same day if personally served, the next Business Day if sent by facsimile or similar means of recorded communication or on the fifth Business Day next following where
sent by registered mail. Notices shall be addressed to the representatives of the parties indicated in the Contract.

25. **Permits and Applicable Laws**

   a) The Vendor shall, at its sole expense, obtain and maintain during the term of the Contract, all permits, licences and approvals required by all Applicable Laws to perform its obligations under the Contract. The terms and conditions of the Contract shall be carried out in strict compliance with all Applicable Laws and in the event of any conflict between any Applicable Laws, the Applicable Laws with the most stringent standard shall apply.

   b) Without limiting the generality of subsection 25(a) above, the Vendor shall comply with the *Personal Information Protection and Electronic Documents Act* (Canada), MFIPPA and any other applicable privacy legislation with respect to any personal information collected, used or disclosed in connection with the Contract and shall indemnify and hold harmless Toronto Hydro and its Representatives from and against any and all claims, demands, suits, losses, damages, causes of action, fines or judgments (including related expenses and legal costs) they may incur related to or arising out of any non-compliance therewith by the Vendor or its Representatives.

26. **Compliance with Guidelines**

   The Vendor’s personnel shall comply with all rules and direction of Toronto Hydro, whether specified in this Agreement or otherwise, while working on Toronto Hydro’s premises, distribution system or when accessing or connecting to Toronto Hydro’s information technology systems, including rules and directions concerning health, safety, security and environmental protection, including without limitation, Toronto Hydro’s *Code of Business Conduct*, Toronto Hydro’s *Disclosure Policy*, Toronto Hydro’s *Social Media and Digital Communication Guidelines*, Toronto Hydro’s *Accessibility Standards for Customer Service Policy*, Toronto Hydro’s *Workplace Harassment Policy*, Toronto Hydro’s *Violence Prevention in the Workplace Policy*, Toronto Hydro’s *Environmental Policy*, Toronto Hydro’s *Occupational Health & Safety Policy*, Toronto Hydro’s *Privacy Policy Statement*, Toronto Hydro’s *Cyber Security Policy*, Toronto Hydro’s *Technology Use Guidelines*, Toronto Hydro’s *External Supplier Access to Application Services* and the *Affiliate Relationships Code for Electricity Distributors and Transmitters* issued by the OEB (together, the “Guidelines”). The Vendor acknowledges that it has been provided with a copy of the Guidelines, has provided and will provide a copy of the Guidelines to each of its Representatives and that it agrees to comply with and to direct its Representatives to comply with such Guidelines, as amended.

27. **Governing Law**

   The Contract shall be governed by and construed in accordance with the laws of the Province of Ontario and the laws of Canada applicable therein. The Parties irrevocably attorn to the jurisdiction of the courts of Ontario with respect to any matter arising under or related to the
Contract. Either party can terminate for cause without the obligation to engage in dispute resolution, mediation, or arbitration.

28. **Further Assurances**

The Vendor agrees to execute such further assurances and documents, including any bills of sale, and to do all such things and actions which shall be necessary or proper for the carrying out of the purposes and intent of the Contract.

29. **Survival**

In addition to the terms of the Contract that by their nature survive the expiry or termination of the Contract, the terms of Sections 10 (Representations and Warranties), 13 (Liability and Indemnification), 16 (Intellectual Property Protection), 17 (Confidential Information), 20 (Severability), 22 (Enurement), 23 (Notice) and 26 (Governing Law) shall survive the expiry or termination of the Contract for a period of five (5) years.

30. **Definitions**

a) In these Standard Terms and Conditions, “Vendor” means the provider of the goods/services under the Contract.

b) Any capitalized terms used in these Standard Terms and Conditions but not defined herein shall have the meaning as defined in the RFP.
SCHEDULE C-2

ADDITIONAL TERMS AND CONDITIONS

1. **Toronto Hydro Not Responsible**

   Notwithstanding any other provision in this Agreement, Toronto Hydro shall not be responsible for and shall not have control or charge of any means, methods, techniques, sequences or procedures used for or in respect of the Services, or for the safety precautions or programs required for the Services or otherwise prescribed hereunder. Toronto Hydro shall not be responsible for or have control or charge over the acts or omissions of the Vendor, subcontractors (if any) or their agents, employees or other persons performing any of the Services.

2. **Suspension**

   Toronto Hydro may, at any time during the term by notice in writing, suspend all or a portion of the Services. Upon receipt of such written notice, the Vendor shall perform no further work other than as directed by Toronto Hydro, and shall be entitled to payment for time spent in performing the Services up to the date of suspension.

3. **Preparation of the Agreement**

   Notwithstanding the fact that this Agreement was drafted by Toronto Hydro and its legal and other profession advisors, the parties acknowledge and agree that any doubt or ambiguity in the meaning, application or enforceability of any term or provision of this Agreement will not be construed or interpreted against Toronto Hydro or in favour of the Vendor when interpreting such term or provision, by virtue of such fact.

4. **Publicity**

   The Vendor shall not use Toronto Hydro’s (or its Affiliates’) name, corporate logos or trade-marks in advertising or publicity nor the fact that any agreement between the Vendor and Toronto Hydro has been entered into without Toronto Hydro’s express prior written consent, which may be withheld in the sole discretion of Toronto Hydro.

5. **No Minimum Volume**

   The Vendor acknowledges and agrees that: (i) no portion of this Agreement shall be interpreted as imposing any minimum volume purchase commitment on Toronto Hydro; (ii) this Agreement does not obligate Toronto Hydro to award the procurement of any or all services associated with this Agreement to the Vendor, and services may be added or deleted in Toronto Hydro’s absolute and sole discretion at any time; and (iii) the volume of purchase of the services may diminish or be eliminated prior to the termination date of this Agreement without any liability on the part of Toronto Hydro, including but not limited to any claims by the Vendor for loss of anticipated profits.

6. **Non-Exclusive Agreement**
It is expressly understood that this Agreement is non-exclusive with respect to the Vendor and Toronto Hydro. Toronto Hydro may contract with others for the procurement of the services described herein in its sole discretion.

7. Resources

(a) Subject to Section (c) below, the successful Respondent shall ensure that all resources designated as required resources (“Required Resources”) in the Contract shall be made available according to the allocations described therein.

(b) Any adjustment by the successful Respondent to the Required Resources shall be subject to the following:

(i) Subject to Section 4(c) below, the successful Respondent shall not substitute or remove a Required Resource at any time without the prior written consent of Toronto Hydro, not to be unreasonably withheld, unless: (A) any such Required Resource terminates his/her employment with the successful Respondent, or (B) the security of Toronto Hydro’s information is at risk and there is no opportunity to obtain prior written consent in such circumstances;

(ii) The successful Respondent shall ensure that each resource substituted for a Required Resource is at a job seniority level and skill level equivalent to or higher than those of the Required Resource;

(iii) The successful Respondent shall ensure that each resource substituted for a Required Resource is introduced in sufficient time prior to the departure of such Required Resource (the “Overlap Period”) so as to learn or become familiar with: (A) the implementation and development of the Services, and (B) those skills and duties necessary to function in place of such Required Resource. All costs incurred in relation to the Overlap Period shall be paid by the successful Respondent.

(iv) The successful Respondent shall provide Toronto Hydro, if requested by Toronto Hydro, with copies of the current curriculum vitae of each Required Resource prior to the assignment of such Required Resource. The successful Respondent shall ensure that the successful Respondent has obtained the written consent of all Required Resources to provide Toronto Hydro with the foregoing information and that Toronto Hydro may distribute such information internally to others employed in connection with the development and implementation of the Services, as required (excluding any personnel, contractors or other individuals employed by or affiliated with a competitor of the successful Respondent).

(c) Notwithstanding Section (a) and (b)(i) above, the Parties acknowledge that the successful Respondent may only substitute the maximum number of Required Resources.

(d) The successful Respondent shall also inform Toronto Hydro of turnover of all personnel within their organization that is connected to the Services being provided by the successful Respondent to Toronto Hydro (whether a Required Resource or not) in a timely fashion, but in no case longer than five (5) Business Days from such effective termination, in order to allow Toronto Hydro to make arrangements for its protection.

8. Ownership of the Deliverables
Subject only to any third party software license for mass-produced software or pre-existing intellectual property of successful Respondent specifically referenced in the Proposal, Contract or any applicable SOW(s), ownership of the intellectual property rights in the deliverables and ownership of any related tangible deliverables shall vest in Toronto Hydro upon their creation, unencumbered subject only to Toronto Hydro’s obligation to pay for such deliverables in accordance with the terms of the Contract. The successful Respondent will cause all applicable employees and independent contractors to have waived all moral rights in the applicable deliverables in favour of Toronto Hydro and its successors, assigns and novatees. Any licenses for the use of third party software shall be consistent with the terms of the Contracts, including as to scope of use. To the extent that any deliverables include pre-existing intellectual property of the successful Respondent, the successful Respondent grants, or will have granted, to Toronto Hydro an irrevocable, worldwide, paid-up license to use such intellectual property in connection with such deliverables for the purposes for which they are reasonably contemplated to be provided pursuant to the Contract.
APPENDIX 1 TO SCHEDULE C-2

PRIVACY TERMS & CONDITIONS

SEE ATTACHED PDF
SCHEDULE D

PROPOSAL COVER SHEET

PROPOSAL

of

_______________________________________

in response to

Toronto Hydro's

RFP No. __________

Date of Submission of Proposal: ________________

Respondent Contact Information:

Company Name: ________________________________
Primary Contact Name: __________________________
Primary Contact Title: ____________________________
Address: __________________________________________
Email: __________________________________________
Telephone: _______________________________________
Fax: ____________________________________________
SCHEDULE E

RESPONDENT'S CERTIFICATE

I, the undersigned, in submitting the accompanying Proposal to Toronto Hydro in response to RFP No. __________ (the “RFP”) on behalf of __________________________________________ (the “Respondent”) do hereby certify, on behalf of the Respondent and not in my personal capacity that:

1. I have read, understand and agree to comply with the terms of this RFP.

2. I have read, understand and agree to comply with the statements made in this Certificate.

3. I understand that the accompanying Proposal may be disqualified if this Certificate is found not to be true and complete in every respect.

4. I am authorized by the Respondent to sign this Certificate, and to submit the accompanying Proposal, on behalf of the Respondent.

5. Each person whose signature appears on the accompanying Proposal has been authorized by the Respondent to determine the terms of, and to sign, the Proposal, on behalf of the Respondent.

6. For the purposes of this Certificate and the accompanying Proposal, I understand that the word “Competitor” shall include any individual or organization, other than the Respondent, whether or not affiliated with the Respondent, who:

   (a) has been requested to submit a Proposal in response to the above-noted RFP; or
   
   (b) could potentially submit a Proposal in response to the above-noted RFP, based on their qualifications, abilities or experience.

7. The Respondent has arrived at the accompanying Proposal independently from, and without consultation, communication, agreement or arrangement with, any Competitor.

8. The terms of the accompanying Proposal have not, and will not be disclosed by the respondent, directly or indirectly, to any Competitor.

9. Any and all potential conflicts of interest between the Respondent and Toronto Hydro (or any Representative thereof) are expressly identified and fully disclosed by the Respondent in the attached Proposal, including the disclosure of any personal or business relationships between the Respondent and Toronto Hydro (or any Representative thereof) and the Respondent (or any Representative thereof).
10. The Respondent, by means of the attached Proposal, hereby offers to enter into a Contract with Toronto Hydro at the prices, and according to the terms and conditions, as set forth in the Proposal and the RFP.

11. Any capitalized terms used in this Certificate but not defined herein shall have the meaning as defined in the RFP.

Respondent’s Full Corporate Name

Authorized Representative’s Signature

Name

Title

Date

Please Affix Respondent’s Corporate Seal Here
SCHEDULE F

DEFINED TERMS

In this RFP, the following definitions shall apply:

“Additional Terms and Conditions” means the terms and conditions, if any, found in SCHEDULE C-2;

“Affiliates” has the meaning prescribed to it in the Business Corporations Act of Ontario;

“Applicable Laws” means all federal, provincial and municipal statutes, regulations, codes, by-laws, orders in council, directives, rules, guidelines and ordinances applicable to this RFP and any resulting Contract, including without limitation all applicable OEB codes, rules or guidelines;

“Business Day” means a day on which banks are open for business in the City of Toronto, Ontario, but does not include a Saturday, Sunday, or a statutory holiday in the Province of Ontario;

“Confidential Information” has the meaning prescribed to it in Section 2.15;

“Contract” means the definitive written agreement, if any, which may be entered into between the successful Respondent and Toronto Hydro, as a result of this RFP process, which may be in the form of an agreement executed by the successful Respondent and Toronto Hydro or, if no such agreement is executed, may be in the form of a purchase order issued by Toronto Hydro to the successful Respondent that shall be deemed to incorporate by reference the Standard Terms and Conditions in SCHEDULE C and the Additional Terms and Conditions in SCHEDULE C-2, if any, subject to any negotiated amendments or modifications thereto acceptable to Toronto Hydro in its discretion;

“Date for Execution of the Contract” has the meaning prescribed to it in SCHEDULE A;

“Date for Selection of Successful Respondent(s)” has the meaning prescribed to it in SCHEDULE A;
“Deadline for Submission of Questions” has the meaning prescribed to it in SCHEDULE A;

“EST” means Eastern Standard Time or Eastern Daylight Time;

“Governmental Authority” means any government, legislature, municipality, regulatory authority, agency, commission, department, board or court or other law, regulation or rule-making public entity of similar authority, including, without limitation the OEB;

“OEB” means Ontario Energy Board;

“Proposal” means the document(s) submitted by a Respondent to the Supply Chain Services Department in response to this RFP;

“Representative” in respect of a party, means such party's directors, officers, employees, agents and contractors, the party's Affiliates, and all such Affiliates' respective directors, officers, employees, agents and contractors;

“Respondent” means each party that submits a Proposal to the Supply Chain Services Department in response to this RFP;

“RFP” means this Request for Proposals, including any and all schedules, attachments, amendments, supplements or revisions thereto;

“Standard Terms and Conditions” means the terms and conditions found in SCHEDULE C;

“Submission Deadline” has the meaning prescribed to it in SCHEDULE A;

“Supply Chain Services Department” means the Supply Chain Services Department of THESL;

“Supply Chain Specialist” means the Representative of the Supply Chain Services Department identified in Section (a) of SCHEDULE A

“THESL” means Toronto Hydro-Electric System Limited;

“Toronto Hydro” has the meaning identified on the cover page of this RFP.
SCHEDULE G

PROPOSAL PRICE FORM

(Proposal Price Form is attached)
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 33:

Reference(s): Exhibit 2B, Section A6, p.32

Please provide a copy of the review and update of Toronto Hydro’s Reliability Centered Maintenance analyses that was undertaken in 2017.

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 2B-BOMA-60.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 34:
Reference(s): Exhibit 2B, Section D1, p.7

Please provide a detailed chronology of material events in Toronto Hydro’s capital planning process for the capital plan included in this application. [Note: For an example of a similar chronology, please see the response to SEC-36 in EB-2017-0049 (Exhibit I, Tab 24, Schedule SEC-36)].

RESPONSE:
Please see 1B-CCC-9 for a description and chronology of the business planning process, which was inclusive of the capital planning process that led to the application and 2020-2024 Distribution System Plan. The key elements, considerations, and results of this process are illustrated and described in detail in Exhibit 2B, Section E2. The Asset Management (AM) process, which is also a critical element of capital planning, and specifically the Investment Planning & Portfolio Reporting (“IPPR”) process described in Exhibit 2B, Section D1, supported and coincided with the business planning chronology as follows:

• In late 2016, Toronto Hydro began the IPPR process, with a focus on principles and strategy, in alignment with feedback from the first phase of customer engagement and efforts to set the organization’s outcomes framework. These activities supported the first two elements of the business planning process discussed in 1B-CCC-9.
• In early 2017, Toronto Hydro began work on its portfolio plan and developed preliminary program investment scenarios. This provided additional support in the development of the outcomes framework and high-level strategic parameters as summarized in the second element of the business planning process in 1B-CCC-9. Please refer to Exhibit 2B, Section E2.1.1 for more details on these high-level considerations and Exhibit 2B, Section E2, pages 4-5 and 15-17 for information on the preliminary scenarios.

• Beginning in the second quarter of 2017, Toronto Hydro reviewed expenditure proposals and alternatives, resulting in the development of initial capital program proposals. These program proposals formed an input into the organization’s broader operational and financial planning activities as summarized in the third element of the business planning process in 1B-CCC-9. These activities, as they pertained to capital planning, are described in Exhibit 2B, Section E2.1.2.

• Following the IPPR process, capital planning for the 2020-2024 period continued within the broader business planning process as articulated in the fourth and fifth points discussed in 1B-CCC-9. These activities, as they pertain to capital planning, are described in Exhibit 2B, Section E2.1.3.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 35:

Reference(s): Exhibit 2B, Section D1, p.7

Please explain how Toronto Hydro’s Asset Management Process outlined in Figure 2 has changed, if at all, from the process that led to its 2015-2019 capital plan.

RESPONSE:

The Asset Management ("AM") process as outlined in Figure 2 (Exhibit 2B, Section D1, page 7), has changed since the EB-2014-0116 application as a result of a number of continuous improvement initiatives. (See Section D1.3.2.) The changes have been motivated by Toronto Hydro’s relentless efforts to improve and have been informed by feedback captured both internally within the utility, as well as from external stakeholders, including the Ontario Energy Board (OEB). Notable changes and improvements include:

- Broader customer engagement activities were leveraged right from the onset of the process that lead to the development of the 2020-2024 capital plan. The AM Process used, which is illustrated in Figure 2, shows how customer engagement information, including information related to customer priorities and preferences, were leveraged to influence Principles, Strategy, and Outcomes.

- The Investment Planning & Portfolio Reporting ("IPPR") process is also newly developed and improves the systematic approach, including the frequency by which certain AM activities are undertaken, and the integrated nature of those activities. For example, the IPPR process encompasses the 2015-2019 AM Planning Process components (Long Term, Short Term and Maintenance Planning processes), develops portfolio plans for both capital and OM&A. The IPPR process
is executed annually and enables more visibility in terms of assessing the capital
programs progress on a yearly basis, in a structured manner.

- **Enterprise systems and decision support systems** continue to be key inputs for
planning activities although they are integrated throughout the process in Figure 2
and are no longer shown as distinct elements as seen in the 2015-2019 capital
plan. Enterprise systems and decision support systems are especially integral to
the Asset Needs Assessment component of the process as it provides the data and
tools needed to make a well-informed assessment of the current state of the
system and forecast potential risks and challenges.

- The **Short Term Planning** process from the 2015-2019 capital plan is also further
expanded in **Scope and Project Development** in Figure 2, which speaks to the
development and refinement of high level scopes to detailed design.
Enhancements in this area include the introduction of a function to further refine
project scope of works and cost estimates prior to detailed design. This process
continues in **Program Management & Execution**, which addresses the creation,
delivery, and governance of the executable work program.

- **Measurement & Enhancement** from the 2015-2019 capital plan is equivalent to
**Performance Measurement** in Figure 2 but has been expanded to also include the
impact of programs on outcome measures created to assess the progress of the
capital and maintenance expenditure plans. This enhancement aligns with
Toronto Hydro’s efforts to more fully embed outcomes into its processes and
provides a means of evaluating outcome measure results, which ultimately inform
future year’s IPPR processes and the portfolios that it produces.

The above comparison of various components of the AM process in Figure 2 (IPPR
process, Scope and Development, Program Management & Execution, and Performance
Measurement) to the AM process that led the 2015-2019 capital plan encompasses a
subset of the overall changes that have occurred. As noted above, recent enhancements as a result of continuous improvement initiatives are noted in Exhibit 2B, Section D1.3.2. They include updates to Reliability Centered Maintenance and Asset Condition Assessment.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 36:

Reference(s): Exhibit 2B, Section D1, p.16

Toronto Hydro states: “Toronto Hydro prioritizes projects within and across programs in accordance with anticipated project benefits, estimated costs, and an assessment of execution capabilities and constraints. On this basis, the lowest priority projects are deferred to future years, and the projects that offer the greatest value-for-money relative to the utility’s customer-focused objectives are scheduled for execution.”

a) Please provide further details regarding how Toronto Hydro prioritizes projects using specific examples.

b) Please provide a list of the 2020 proposed projects on a prioritized basis, with all measures used in the prioritization process.

c) Please explain how Toronto Hydro determined “value-for-money”.

d) Does Toronto Hydro use a prioritization tool or system (e.g. CopperLeaf)? If so, please provide details including a copy of any internal documents describing how the tool should be used.

RESPONSE:

a) Toronto Hydro develops projects by following a systematic approach as described in the Asset Management Process in Exhibit 2B, Section D1. Planners use various tools...
and inputs including asset age, condition, historical reliability, and customer preferences to develop projects. Toronto Hydro’s response to interrogatory 2B-Staff-67(e) provides further details on how various tools interact to direct capital expenditures. Once projects are developed, Toronto Hydro relies on its Program Management and Execution process to ensure projects are prioritized accordingly.

Particularly, the Execution Work Program (“EWP”) development as part of Work Program Management, as detailed in Exhibit 4A, Tab 2, Schedule 9, is integral in establishing the projects selected for execution for a particular year. All project scopes proposed for any particular program in a given year are assessed against constraints for execution as detailed in Exhibit 2B, Section D1.2.3, page 19, including consultation with internal and external stakeholders, labour balancing, moratoriums, and third party coordination. As part of the EWP development process, system planners and program managers work together to establish an optimized set of projects to be executed for a given year based on the objectives and outcomes for the program. Through this process, planners and program managers would ultimately identify projects that provide the best value as described in part (c) of this response. The EWP process is iterative in nature and begins with a draft list being produced at the onset of the process based on the considerations described above. The set of projects undergo continuous refinements leading up to the year of execution as field conditions, impact on outcomes, or customer needs change.

As an example, Table 1 contains projects that were proposed to be included in the 2018 EWP under the Network Unit Renewal program, along with a subset of factors that were considered when the 2018 program was being finalized.
The projects were assessed, including the factors listed (e.g. condition, PCBs), and they were compared against all available projects, prior to the finalization of the optimized set of projects for execution in 2018. Using the example projects in the Table above, all three Network Units are past their useful life, however, project X18115 addresses units that show signs of minor oil leaks (including on the base of the transformer) and that

### Table 1: Summary of Project Status

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Project Title</th>
<th>Asset Needs Assessment: Factors or Tools Considered</th>
<th>Included in 2018 EWP</th>
</tr>
</thead>
</table>
| X18114      | X18114 Yonge St/Glen Elm Ave, Network Unit Upgrade, Elec. 4039 TOA66DX        | Age: 1980  
Condition:  
- TX – HI3  
- Protector – HI1  
- Oil Leaks/Corrosion: Yes – minor corrosion  
Fibertop: Yes  
PCB: No  
Other Factors: Vault rebuild not required | No. To be considered for 2019 |
| X18115      | X18115 Network Change Out Loc4808NV/SV (4 units) A70,71,72,73A TOA70A         | Age: 1971  
Condition:  
- 1 TX – HI1, 1TX – HI2, 2TXs – HI4  
- 2 Protectors – HI1, 2 Protectors – HI3  
- Oil Leaks/Corrosion: Yes – minor leaks including base leak  
Fibertop: No  
PCB: Yes  
Other Factors: Vault rebuild not required | Yes |
| X18122      | X18122 Network Change Out Loc 4026, A82CS Bay/St Mary TOA82CS                 | Age: 1960  
Condition:  
- TX – HI2  
- Protector – HI4  
- Oil Leaks/Corrosion - No  
Fibertop: Yes  
PCB: No  
Other Factors: Vault rebuild not required | No. To be considered for 2019 |
also contain PCBs. Project X18115 was given a higher priority even though the other two projects (X18114 and X18122) both contain fibertop units, and X18122 has an older asset. As a result, X18115 was included in the list for execution in 2018, while the other two projects were left for consideration at a subsequent time (i.e. 2019).

The example presented extends to projects proposed as part of other capital investment programs. When developing the overall EWP, a very broad set of factors are considered, some of which are highly specific to particular projects, including execution constraints such as the need to schedule feeder outages, moratoriums, and third party coordination, as discussed in Exhibit 4A, Tab 2, Schedule 9.

b) Toronto Hydro does not produce a prioritized list of projects and does not maintain an exhaustive list of all measures used. Projects that are identified for inclusion in a particular year’s EWP (i.e. work program) are not set until just prior to the execution year beginning. This is done using the EWP development process discussed in part (a) above.

As of the beginning of 2019, Toronto Hydro has an early draft set of projects that will be considered in late 2019 for the final Execution Work Program for 2020. This draft is not in the form of a prioritized list. Given the dynamic nature of planning and executing a large capital program, the draft set of projects is expected to change considerably between now and the end of the year.

c) “Value-for-money” in the context quoted refers broadly to various types of cost-benefit analyses. As discussed in the response to part (a), the utility determines value-for-money at the project level by weighing the costs of a project relative to its contributions to asset risk mitigation and other various other customer-focused benefits (e.g.
reliability), and leveraging the utility’s various asset management decision support tools and planning processes.

d) Toronto Hydro does not use an automated prioritization system such as a Copperleaf.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 37:

Reference(s): Exhibit 2B, Section D1, p.17-18

Please provide step-by-step details regarding how Toronto Hydro estimates project costs.
Please provide examples to illustrate.

RESPONSE:

To develop project cost estimates, Toronto Hydro follows three steps (all within the AM Process, illustrated in Exhibit 2B, Section D1, at page 7). The estimate begins at the (i) “Creation of High-Level Scopes of Work” stage, is refined at (ii) “Refinement of Scope and Cost Estimation” stage (refer to 2B-BOMA-108), and finalized in a detailed estimate at the “Execution of Work” stage. These stages are described in Exhibit 2B, Section D1, at pages 17 to 19. The following details how estimates are produced using Box Conversion as an example.

1) **Creation of High Level Scopes of Work**

Once a planner is ready to create a high level scope of work, the planner will have already identified the specific area, feeder(s), and cost drivers for the work. For Box Conversion, the planner will begin by identifying the number of poles that will need to be replaced and will then quantify the number of major assets that the scope will entail (e.g. conductor, transformers, switches). In some cases, a field visit will be required to validate or better evaluate existing field conditions and assets, as available tools such as available tools such the Geographic Information System (GIS) may be limited. One example is a project where the
planner identified the following quantities of major assets: 2,960 metres of primary cable, 4,800 metres of secondary cable, 145 poles, 21 switches, and 38 transformers.

After the quantities of major assets are identified, the planner uses Toronto Hydro’s Enterprise Resource Planning system (i.e. SAP) to apply assembly units (i.e. labour, material, and tool dollars) to determine overall costs for replacing each of the assets. The planner will specifically select assembly units that apply to the particular assets contained in the scope (e.g. specific size and type of transformer; specific size of conductor). For the particular project referenced above, the following table contains the high level cost estimate components.

### Table 1: Summary of Major Asset Costs

<table>
<thead>
<tr>
<th>Major Asset</th>
<th>Cost ($ Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor</td>
<td>1.3</td>
</tr>
<tr>
<td>Poles</td>
<td>0.7</td>
</tr>
<tr>
<td>Switches</td>
<td>0.2</td>
</tr>
<tr>
<td>Transformers</td>
<td>0.5</td>
</tr>
<tr>
<td>Other Civil</td>
<td>0.6</td>
</tr>
<tr>
<td>Civil</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.3</strong></td>
</tr>
</tbody>
</table>

2) Refinement of Scope and Cost Estimation

Once the high-level scope of work and estimate has been produced, Toronto Hydro utilizes a cross-functional team of engineers, designers, and field staff to refine the scope and estimate. This team conducts a field visit, produces a conceptual design, and conducts a more thorough analysis of the scope of work and specifically the risks to project execution (e.g. acquiring permits, coordination with third parties, city road moratoriums, physical restrictions, and design challenges).
At this stage, a more detailed, bottom-up, cost estimate is produced beginning with more refined asset quantities. For example, the project referenced above may see its asset quantities change at this stage. The table below contains the updated list of asset quantities. (Please note that some of the specific asset quantities changed considerably during the refinement stage.) Assembly units would then be applied to this updated set of units to arrive at a refined cost estimate.

Table 2: Updated Project Asset Quantities

<table>
<thead>
<tr>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>85</td>
</tr>
<tr>
<td>Switches</td>
<td></td>
</tr>
<tr>
<td>Fuse</td>
<td>16</td>
</tr>
<tr>
<td>Disconnect</td>
<td>0</td>
</tr>
<tr>
<td>Load Break</td>
<td>2</td>
</tr>
<tr>
<td>SCADA</td>
<td>3</td>
</tr>
<tr>
<td>Conductor</td>
<td></td>
</tr>
<tr>
<td>336kcmil (tree proof)</td>
<td>5,500</td>
</tr>
<tr>
<td>3/0 Tree-Proof (tree proof)</td>
<td>4,800</td>
</tr>
<tr>
<td>Secondary Bus (m)</td>
<td>4,600</td>
</tr>
<tr>
<td>Secondary Service (m)</td>
<td>0</td>
</tr>
<tr>
<td>Transformer</td>
<td></td>
</tr>
<tr>
<td>Overhead</td>
<td>34</td>
</tr>
<tr>
<td>Vault</td>
<td>1</td>
</tr>
<tr>
<td>Pad Mount</td>
<td>1</td>
</tr>
<tr>
<td>Cable</td>
<td></td>
</tr>
<tr>
<td>Primary (m)</td>
<td>1500</td>
</tr>
<tr>
<td>Secondary Bus (m)</td>
<td>80</td>
</tr>
<tr>
<td>Civil</td>
<td></td>
</tr>
<tr>
<td>Concrete Encased duct bank (m)</td>
<td>85</td>
</tr>
</tbody>
</table>
3) **Detailed Design Estimate**

At the time of project execution, the scope of work along with the refined estimate from stage 2 above are taken and used to produce a detailed design. The detailed design considers additional details (e.g. area-specific factors such as trees, obstacles, landscapes) and ultimately produces the drawings that will be used by field staff to construct the project. Using the detailed design, a detailed estimate is created.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 38:

Reference(s): Exhibit 2B, Section D2

With respect to useful life:

a) Please define useful life.

b) How has Toronto Hydro determined the useful life of its assets?

c) When was the last time Toronto Hydro undertook a Depreciation Study? Please provide a copy of that study.

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-12.

b) Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-12.

c) Toronto Hydro engaged Kinectrics Inc. to undertake a study of useful lives, for a subset of its assets, in 2009. Please refer to Appendix A for a copy of study.
Toronto Hydro Electric System
Useful Life of Assets

Kinectrics Inc. Report No: K-418021-RA-0001-R002

August 28, 2009

Confidential & Proprietary Information
Contents of this report shall not be disclosed
without authority of client.
Kinectrics Inc.
800 Kipling Avenue
Toronto, ON
M8Z 6C4 Canada
www.kinectrics.com
DISCLAIMER

Kinectrics Inc. has prepared this report in accordance with, and subject to, the terms and conditions of the agreement between Kinectrics Inc. and Toronto Hydro Electric System.

@Kinectrics Inc., 2009.
Toronto Hydro Electric System
Useful Life of Assets

Kinectrics Inc. Report No: K-418021-RA-0001-R002

August 28, 2009

Prepared by:

______________________________
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Distribution and Asset Management Department

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Distribution and Asset Management Department

Reviewed by:

______________________________
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Principal Engineer
Distribution and Asset Management Department

Approved by:

______________________________
Yury Tsimberg
Director – Asset Management
Transmission and Distribution Technologies

Dated: __________________________
August 28, 2009

iii
Rev 001

Revision History

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<th>Date</th>
<th>Comments</th>
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<td>August 21, 2009</td>
<td>Initial Draft</td>
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<td>August 27, 2009</td>
<td>THESL comments incorporated.</td>
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<td>R002</td>
<td>August 28, 2009</td>
<td>Final Report</td>
<td>Y. Tsimberg</td>
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# Table of Contents

Table of Contents .............................................................................................................. v
1 Executive Summary ........................................................................................................... 1
  1.1 Introduction .................................................................................................................. 1
  1.2 Project Scope ............................................................................................................... 1
  1.3 Project Execution Process ............................................................................................ 1
  1.4 Definition of Terms ...................................................................................................... 2
  1.5 Summary of Findings .................................................................................................... 4
2 Wood Pole (Fully Dressed) ............................................................................................... 8
  2.1 Degradation Mechanism ............................................................................................. 8
  2.2 System Hierarchy ........................................................................................................ 8
  2.3 Useful Life and Typical Life ......................................................................................... 8
  2.4 Time Based Maintenance Intervals ............................................................................ 8
3 Concrete poles .................................................................................................................. 9
  3.1 Degradation Mechanism ............................................................................................ 9
  3.2 System Hierarchy ....................................................................................................... 9
  3.3 Useful Life and Typical Life ....................................................................................... 9
  3.4 Time Based Maintenance Intervals ............................................................................ 9
4 Remotely Operated Overhead Switch ............................................................................ 10
  4.1 Degradation Mechanism ........................................................................................... 10
  4.2 System Hierarchy ....................................................................................................... 10
  4.3 Useful Life and Typical Life ....................................................................................... 10
  4.4 Time Based Maintenance Intervals ............................................................................ 10
5 Manually Operated Overhead Switch ............................................................................ 11
  5.1 Degradation Mechanism ........................................................................................... 11
  5.2 System Hierarchy ....................................................................................................... 11
  5.3 Useful Life and Typical Life ....................................................................................... 11
  5.4 Time Based Maintenance Intervals ............................................................................ 11
6 SCADAMATE Overhead Switch .................................................................................... 12
  6.1 Degradation Mechanism ........................................................................................... 12
  6.2 System Hierarchy ....................................................................................................... 12
  6.3 Useful Life and Typical Life ....................................................................................... 12
  6.4 Time Based Maintenance Intervals ............................................................................ 12
7 Overhead Primary Conductor ......................................................................................... 13
  7.1 Degradation Mechanism ........................................................................................... 13
  7.2 System Hierarchy ....................................................................................................... 14
  7.3 Useful Life and Typical Life ....................................................................................... 14
    7.3.1 Primary Bare ....................................................................................................... 14
    7.3.2 Primary Tree Proof ............................................................................................ 14
8 Overhead Secondary Conductors .................................................................................... 15
  8.1 Degradation Mechanism ........................................................................................... 15
  8.2 System Hierarchy ....................................................................................................... 15
  8.3 Useful Life and Typical Life ....................................................................................... 15
9 Pole Mounted Transformer ............................................................................................. 16
  9.1 Degradation Mechanism ........................................................................................... 16
  9.2 System Hierarchy ....................................................................................................... 16
  9.3 Useful Life and Typical Life ....................................................................................... 16
10 Lighting Assemblies (High Mast) .................................................................................. 17
10.1 Degradation Mechanism ................................................................. 17
10.2 System Hierarchy .......................................................................... 17
10.3 Useful Life and Typical Life .......................................................... 17
  10.3.1 High Mast Pole ...................................................................... 17
  10.3.2 Cabling ............................................................................... 17
  10.3.3 Luminaires .......................................................................... 17
10.4 Time Based Maintenance Intervals ............................................. 17
11 Power Transformer (>10 MVA, >50kV) ............................................ 18
  11.1 Degradation Mechanism ............................................................... 18
  11.2 System Hierarchy ....................................................................... 18
  11.3 Useful Life and Typical Life ....................................................... 18
    11.3.1 Winding System .................................................................. 19
    11.3.2 Bushings .......................................................................... 19
    11.3.3 Tap Changer ..................................................................... 19
  11.4 Time Based Maintenance Intervals ............................................. 19
12 230 kV Steel Structures & Overhead Bus Work ................................ 20
  12.1 Degradation Mechanism ............................................................... 20
  12.2 System Hierarchy ....................................................................... 20
  12.3 Useful Life and Typical Life ....................................................... 20
    12.3.1 230 kV Steel Structures ...................................................... 20
    12.3.2 230 kV Overhead Busbars .................................................. 21
13 Outdoor Station Disconnect Switch (230 kV) ................................ 22
  13.1 Degradation Mechanism ............................................................... 22
  13.2 System Hierarchy ....................................................................... 23
  13.3 Useful Life and Typical Life ....................................................... 23
  13.4 Time Based Maintenance Intervals ............................................. 23
14 Transmission Station (TS) AC Station Service ................................ 24
  14.1 Degradation Mechanism ............................................................... 24
  14.2 System Hierarchy ....................................................................... 24
  14.3 Useful Life and Typical Life ....................................................... 24
    14.3.1 Transformer ....................................................................... 24
    14.3.2 LV Switchgear ................................................................... 24
  14.4 Time Based Maintenance Intervals ............................................. 24
15 Power Transformer (>2.5MVA and <10MVA), <50kV) ....................... 25
  15.1 Degradation Mechanism ............................................................... 25
  15.2 System Hierarchy ....................................................................... 25
  15.3 Useful Life and Typical Life ....................................................... 25
    15.3.1 Winding ........................................................................... 25
    15.3.2 Bushings .......................................................................... 25
    15.3.3 Tap Changer ..................................................................... 25
  15.4 Time Based Maintenance Intervals ............................................. 25
16 Station Steel Structures & Overhead Bus Work (<50kV) ....................... 26
  16.1 Degradation Mechanism ............................................................... 26
  16.2 System Hierarchy ....................................................................... 26
  16.3 Useful Life and Typical Life ....................................................... 26
17 Outdoor Station Disconnect Switch (<50kV) ...................................... 27
  17.1 Degradation Mechanism ............................................................... 27
  17.2 System Hierarchy ....................................................................... 27
  17.3 Useful Life and Typical Life ....................................................... 27
  17.4 Time Based Maintenance Intervals ............................................. 27
18 Municipal Station (MS) AC Station Service ..................................... 28
Toronto Hydro Electric System Useful Life of Assets

27.3 Useful Life and Typical Life ................................................................. 40
27.4 Time Based Maintenance Intervals ......................................................... 40
28 Air Magnetic Circuit Breaker (Indoor)......................................................... 41
28.1 Degradation Mechanism ...................................................................... 41
28.2 System Hierarchy ................................................................................. 41
28.3 Useful Life and Typical Life .................................................................. 41
28.4 Time Based Maintenance Intervals ......................................................... 41
29 Metalclad / Metal Enclosed Switchgear (Air) ............................................ 42
29.1 Degradation Mechanism ...................................................................... 42
29.2 System Hierarchy ................................................................................. 42
29.3 Useful Life and Typical Life .................................................................. 42
29.4 Time Based Maintenance Intervals ......................................................... 42
30 Metalclad / Metal Enclosed Switchgear (GIS) .......................................... 44
30.1 Degradation Mechanism ...................................................................... 44
30.2 System Hierarchy ................................................................................. 44
30.3 Useful Life and Typical Life .................................................................. 44
30.4 Time Based Maintenance Intervals ......................................................... 44
31 Station Grounding System ...................................................................... 46
31.1 Degradation Mechanism ...................................................................... 46
31.2 System Hierarchy ................................................................................. 46
31.3 Useful Life and Typical Life .................................................................. 46
32 Station Grounding Transformer .............................................................. 47
32.1 Degradation Mechanism ...................................................................... 47
32.2 System Hierarchy ................................................................................. 47
32.3 Useful Life and Typical Life .................................................................. 47
32.4 Time Based Maintenance Intervals ......................................................... 47
33 SCADA RTU ...................................................................................... 48
33.1 Degradation Mechanism ...................................................................... 48
33.2 System Hierarchy ................................................................................. 48
33.3 Useful Life and Typical Life .................................................................. 48
34 Automatic Transfer Switch (ATS) ........................................................... 49
34.1 Degradation Mechanism ...................................................................... 49
34.2 System Hierarchy ................................................................................. 49
34.3 Useful Life and Typical Life .................................................................. 49
34.4 Time Based Maintenance Intervals ......................................................... 49
35 Network Transformer ........................................................................... 50
35.1 Degradation Mechanism ...................................................................... 50
35.2 System Hierarchy ................................................................................. 50
35.3 Useful Life and Typical Life .................................................................. 50
35.3.1 Network Transformer ...................................................................... 51
35.3.2 Network Protector ........................................................................... 51
35.4 Time Based Maintenance Intervals ......................................................... 51
36 Pad Mounted Transformer ...................................................................... 52
36.1 Degradation Mechanism ...................................................................... 52
36.2 System Hierarchy ................................................................................. 52
36.3 Useful Life and Typical Life .................................................................. 52
37 Vault Transformer .................................................................................. 53
37.1 Degradation Mechanism ...................................................................... 53
37.2 System Hierarchy ................................................................................. 53
37.3 Useful Life and Typical Life .................................................................. 53
37.4 Time Based Maintenance Intervals ......................................................... 53
| 38 | Submersible Transformer | ................................................................. | 54 |
| 38.1 | Degradation Mechanism | ..................................................................... | 54 |
| 38.2 | System Hierarchy | ..................................................................... | 54 |
| 38.3 | Useful Life and Typical Life | ................................................................. | 54 |
| 38.4 | Time Based Maintenance Intervals | ..................................................................... | 54 |
| 39 | Network Vault | ..................................................................... | 55 |
| 39.1 | Degradation Mechanism | ..................................................................... | 55 |
| 39.2 | System Hierarchy | ..................................................................... | 55 |
| 39.3 | Useful Life and Typical Life | ................................................................. | 55 |
| 39.3.1 | Roof | ..................................................................... | 55 |
| 39.4 | Time Based Maintenance Intervals | ..................................................................... | 55 |
| 40 | Radial Vault | ..................................................................... | 56 |
| 40.1 | Degradation Mechanism | ..................................................................... | 56 |
| 40.2 | System Hierarchy | ..................................................................... | 56 |
| 40.3 | Useful Life and Typical Life | ................................................................. | 56 |
| 40.3.1 | Roof | ..................................................................... | 56 |
| 40.4 | Time Based Maintenance Intervals | ..................................................................... | 56 |
| 41 | Underground Residential Distribution (URD) Vault | ................................................................. | 57 |
| 41.1 | Degradation Mechanism | ..................................................................... | 57 |
| 41.2 | System Hierarchy | ..................................................................... | 57 |
| 41.3 | Useful Life and Typical Life | ................................................................. | 57 |
| 41.3.1 | Roof | ..................................................................... | 57 |
| 41.4 | Time Based Maintenance Intervals | ..................................................................... | 57 |
| 42 | Submersible Vault | ..................................................................... | 58 |
| 42.1 | Degradation Mechanism | ..................................................................... | 58 |
| 42.2 | System Hierarchy | ..................................................................... | 58 |
| 42.3 | Useful Life and Typical Life | ................................................................. | 58 |
| 42.3.1 | Roof | ..................................................................... | 58 |
| 42.4 | Time Based Maintenance Intervals | ..................................................................... | 58 |
| 43 | Cable Chamber | ..................................................................... | 59 |
| 43.1 | Degradation Mechanism | ..................................................................... | 59 |
| 43.2 | System Hierarchy | ..................................................................... | 59 |
| 43.3 | Useful Life and Typical Life | ................................................................. | 59 |
| 43.3.1 | Roof | ..................................................................... | 60 |
| 43.4 | Time Based Maintenance Intervals | ..................................................................... | 60 |
| 44 | Duct Bank | ..................................................................... | 61 |
| 44.1 | Degradation Mechanism | ..................................................................... | 61 |
| 44.2 | System Hierarchy | ..................................................................... | 61 |
| 44.3 | Useful Life and Typical Life | ................................................................. | 61 |
| 45 | Padmounted Switchgear (SF6/Vacuum) | ................................................................. | 62 |
| 45.1 | Degradation Mechanism | ..................................................................... | 62 |
| 45.2 | System Hierarchy | ..................................................................... | 62 |
| 45.3 | Useful Life and Typical Life | ................................................................. | 62 |
| 45.4 | Time Based Maintenance Intervals | ..................................................................... | 62 |
| 46 | Padmounted Switchgear (Air Insulated) | ................................................................. | 63 |
| 46.1 | Degradation Mechanism | ..................................................................... | 63 |
| 46.2 | System Hierarchy | ..................................................................... | 63 |
| 46.3 | Useful Life and Typical Life | ................................................................. | 63 |
| 46.4 | Time Based Maintenance Intervals | ..................................................................... | 63 |
| 47 | SF6/Vacuum Underground Switches | ................................................................. | 64 |
| 47.1 | Degradation Mechanism | ..................................................................... | 64 |
1 Executive Summary

1.1 Introduction

Local Distribution Companies (LDCs) own and operate a significant number of assets that are typically divided into various asset categories. Additionally, some assets are comprised of several main components that have differing degradation mechanisms and resultant useful life. It is therefore important for LDCs to properly account for the useful lives of assets and their components so that the proper assessments required under International Financial Reporting Standards (IFRS) can be conducted.

This report reviews the useful lives of the assets, and the respective components, that are applicable to Toronto Hydro Electric System Limited (THESL) and Street Lighting. This study is based on available industry information and Kinectrics Inc. (Kinectrics) experience. Useful lives are dependent on a number of factors; these are described in Section 1.4 of this report. These values are compiled from several different sources, namely, industrial statistics, research studies and reports (either by individuals or working groups such as CIGRE) as listed in Section 54 of this report, and Kinectrics experience. The useful lives of assets do not generally follow standard distribution curves; they are derived from empirical statistics.

1.2 Project Scope

This report provides an in-depth evaluation of the useful lives of the assets that are owned and operated by THESL, as well as street lighting assemblies. The typical system(s) to which the asset belongs is given. These “parent” systems are: Overhead Lines (OH), Transmission Stations (TS), Municipal Stations (MS), and Underground Systems (UG). Furthermore, the long term degradation mechanism of each asset category is discussed. Where possible, assets are sub-categorized into components. Note that for an asset that is componentized, only components that have major influences on the useful life of the asset are given. For each asset or component, the following information is presented:

- End of life criteria
- Useful Life Range
- Typical Life
- Typical time-based maintenance intervals, if applicable

Section 1.4 provides definitions for the above terms, as well as descriptions of typical distribution system assets and asset components.

1.3 Project Execution Process

The project execution process entailed a number of steps to ensure that the industry-based information compiled by Kinectrics not only includes all the relevant assets and
components used by THESL, but also that it addresses the specific needs related to the IFRS review. The procedure is as follows:

1. The initial list of assets and components was produced by THESL and Street Lighting and provided to Kinectrics for review.

2. Upon review of the initial list, Kinectrics generated an intermediate asset list that had a somewhat different background, granularity, and componentization, based on industry practices and Kinectrics experience.

3. The intermediate list was reviewed by the THESL operations and Street Lighting and finalized in conjunction with Kinectrics to derive a “final” list.

4. For each asset and component in the “final” list, Kinectrics then gathered the information described in Section 1.2 using the methodology described in Section 1.1 of this report. A Draft Report that summarized the findings and provided detail descriptions, including degradation mechanisms and applicable assumptions for each asset, was produced.

5. THESL operations and Street Lighting reviewed the Draft Report and their comments and feedback were incorporated in this Final Report.

1.4 Definition of Terms

Typical Distribution System Asset
Typical distribution system assets include transformers, breakers, switches, underground cables, poles, vaults, cable chambers, etc. Some of the assets, such as power transformers, are rather complex systems and include a number of components.

Component
For the purposes of this study, component refers to the sub-category of an asset that meets both of the following criteria:

1. Its value is significant enough, relative to the asset value.

2. A need to replace the component does not necessarily warrant replacing the entire asset (i.e. different useful life for each component).

An asset may be comprised of more than one component, each with an independent failure mode and degradation mechanism that may result in a substantially different useful life than the overall asset. A component may also have an independent maintenance and replacement schedule.

End of Life Criteria
This is a condition that results in an asset not being able to perform its intended design functions, as a result of the long-term degradation of the asset or its component(s).
Useful Life
Useful Life refers to an estimated range of years during which an electric utility asset or its component is expected to operate as designed, without experiencing major functional degradation that requires major refurbishment or replacement.

In this report, the useful life range, in years, is presented in terms of a minimum, maximum, and typical value. An overwhelming number of units within a population will perform their intended design functions for a period of time greater than or equal to the minimum life. Conversely, an overwhelming number of units will cease to perform as designed at or beyond the maximum life. A majority of the population will have useful lives of around the typical life. For example, consider an asset class with a useful life range of 20 to 40 years, and a typical life of 30 years. An overwhelming majority of the units within this class will perform as required for at least 20 years. Very little number units will operate beyond 40 years. Finally, a majority of the units within the population will operate for approximately 30 years. Note that an asset category can have a typical life that is equal to either the maximum or minimum life. This is simply an indication that the majority of the units within a population will be operational for either the minimum or maximum years; i.e. the statistical data is skewed towards either the maximum or minimum values. The range in useful lives reflects differences in:

- Operating regimes
- Maintenance practices
- Environmental conditions
- Design specifications

Typical Life
Refers to the typical age at which the asset or component fails. This may vary depending on a utility’s maintenance practices, environmental conditions, and operational stresses.

Typical Time-based Maintenance Intervals
For the purposes of this report, time-based maintenance refers to either Routine Inspections (RI) or Routine Testing/Maintenance (RTM). Other maintenance techniques such as Condition Based Maintenance, Reliability Centered Maintenance, and more intrusive periodic overhauls are very much dependent on individual utility’s maintenance strategy and practices and, as such, could not be included in compiling industry-wide typical values.

Typical time-based maintenance intervals will be given only for assets that are proactively maintained, i.e. assets for which useful life is affected by regular planned maintenance. This excludes assets that are not routinely maintained.
1.5 Summary of Findings
Table 1-1 summarizes useful and typical lives and time based maintenance schedules, for THESL’s assets.

<table>
<thead>
<tr>
<th>Report Section #</th>
<th>Asset Category</th>
<th>Componentization (Sub-category)</th>
<th>Parent*</th>
<th>Typical Asset Size</th>
<th>Useful Life (years)</th>
<th>Maintenance Type**</th>
<th>Time Based Maintain Schedule (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Wood Pole (Fully Dressed)</td>
<td>OH</td>
<td>40 feet</td>
<td>40</td>
<td>44</td>
<td>50</td>
<td>RI</td>
</tr>
<tr>
<td>3</td>
<td>Concrete Pole</td>
<td>OH</td>
<td>40 feet</td>
<td>50</td>
<td>60</td>
<td>60</td>
<td>RI</td>
</tr>
<tr>
<td>4</td>
<td>Remotely Operated Overhead Switch</td>
<td>OH</td>
<td>Not Available</td>
<td>30</td>
<td>45</td>
<td>50</td>
<td>RTM</td>
</tr>
<tr>
<td>5</td>
<td>Manually Operated Overhead Switch</td>
<td>OH</td>
<td>BODA, 28kV, SWITCH, MANUAL, UPRIGHT XTG</td>
<td>30</td>
<td>50</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>6</td>
<td>SCADAMATE Overhead Switch</td>
<td>OH</td>
<td>SWITCH, 28kV, 600A, SCADA CONTROLLED</td>
<td>30</td>
<td>45</td>
<td>50</td>
<td>RTM</td>
</tr>
<tr>
<td>7</td>
<td>Overhead Primary Conductor</td>
<td>Primary Bare</td>
<td>OH</td>
<td>WIRE 553 ASC (DAHLIA') AS PER THESL SPEC</td>
<td>50</td>
<td>60</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Primary Tree Proof</td>
<td>OH</td>
<td>CABLE 336 ASC 15kV TREE PROOF</td>
<td>50</td>
<td>60</td>
<td>77</td>
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<td>8</td>
<td>Overhead Secondary Conductor</td>
<td>OH</td>
<td>TRIPLEX 2- 233.3 AL/XLPEI 1- 300 stock code # 7165236</td>
<td>50</td>
<td>60</td>
<td>77</td>
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<td>9</td>
<td>Pole Mounted Transformer</td>
<td>Pole (High Mast)</td>
<td>OH</td>
<td>POLEMOUNT, 1PH, 100kVA, 15kV</td>
<td>30</td>
<td>40</td>
<td>40</td>
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<tr>
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<td>Lighting Assemblies (High Mast)</td>
<td>Pole (Highmast)</td>
<td>OH</td>
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<td>60</td>
<td>70</td>
<td>80</td>
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<tr>
<td></td>
<td>Cabling</td>
<td>OH</td>
<td>Not Available</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Luminaries</td>
<td>OH</td>
<td>Not Available</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>2</td>
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<tr>
<td>11</td>
<td>Power Transformer (&gt;10MVA, &gt;50kV)</td>
<td>Overall</td>
<td>TS</td>
<td>76/100/125MVA, 230kV/26kV</td>
<td>32</td>
<td>45</td>
<td>65</td>
</tr>
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<td></td>
<td>Winding</td>
<td>TS</td>
<td>32</td>
<td>45</td>
<td>65</td>
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<tr>
<td></td>
<td>Bushing</td>
<td>TS</td>
<td>12</td>
<td>15</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap changer</td>
<td>TS</td>
<td>20</td>
<td>30</td>
<td>35</td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>230 kV Steel Structures and Overhead Bus Work</td>
<td>Steel structure</td>
<td>TS</td>
<td>CAVEAGONG TS</td>
<td>35</td>
<td>50</td>
<td>100</td>
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<tr>
<td></td>
<td>Busbar</td>
<td>TS</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td></td>
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<tr>
<td>13</td>
<td>Outdoor Station Disconnect Switch (230kV)</td>
<td></td>
<td>TS</td>
<td>1200A, 230kV</td>
<td>30</td>
<td>45</td>
<td>50</td>
</tr>
</tbody>
</table>

* OH = Overhead Lines System  ** TS = Transmission Station  ** MS = Municipal Station  ** UG = Underground System  
** RI = Routine Inspection  ** RTM = Routine Testing/Maintenance
# Executive Summary

<table>
<thead>
<tr>
<th>Report Section #</th>
<th>Asset Category</th>
<th>Componentization (Sub-category)</th>
<th>Parent*</th>
<th>Typical Asset Size</th>
<th>Useful Life (years)</th>
<th>Maintenance Type™</th>
<th>Time Based Maintain Schedule (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>TS AC Station Service</td>
<td>Transformer</td>
<td>TS</td>
<td>300 kVA</td>
<td>32</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>15</td>
<td>Power Transformer (&lt;2.5 MVA and &lt;10 MVA, &lt;50 kV)</td>
<td>Overall</td>
<td>MS</td>
<td>5/6.7 MVA, 27.6 kV</td>
<td>32</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>16</td>
<td>Station Steel structures and Overhead Bus Work (&lt;50 kV)</td>
<td>Bus structure for 27.6 kV/480 kV for 2 of 5 MVA transformers</td>
<td>MS</td>
<td></td>
<td>35</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>17</td>
<td>Outdoor Station Disconnect Switch (&lt;50 kV)</td>
<td>Transformer</td>
<td>MS</td>
<td>600 A, 27.6 kV</td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>18</td>
<td>MS AC Station Service</td>
<td>Transformer</td>
<td>MS</td>
<td>75 kVA</td>
<td>32</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>19</td>
<td>DC Station Service</td>
<td>Overall</td>
<td>TS, MS</td>
<td>85-100 VA, 125 V</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>Indoor Station Disconnect Switch (&lt;50 kV)</td>
<td>Battery bank</td>
<td>TS, MS</td>
<td>To be matched with battery size</td>
<td>20</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>21</td>
<td>Oil Breaker (Outdoor)</td>
<td>TS, MS</td>
<td>800 A Gang, LBS, 4 kV</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>RI</td>
</tr>
<tr>
<td>22</td>
<td>SFE Breaker (Outdoor)</td>
<td>TS, MS</td>
<td>1200 A, 13.8 kV</td>
<td>30</td>
<td>42</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>23</td>
<td>Vacuum Breaker (Outdoor)</td>
<td>TS, MS</td>
<td>2500 A, 13.8 kV or 1200 A, 27.6 kV</td>
<td>30</td>
<td>42</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>24</td>
<td>Oil Breaker (Indoor)</td>
<td>TS, MS</td>
<td>3000 A, 13.8 kV or 1200 A, 27.6 kV</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>25</td>
<td>SFE Breaker (Indoor)</td>
<td>TS, MS</td>
<td>1200 A, 13.8 kV</td>
<td>30</td>
<td>42</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>26</td>
<td>Vacuum Breaker (Indoor)</td>
<td>TS, MS</td>
<td>1200 A, 13.8 kV</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>27</td>
<td>Air Blast Breaker (Indoor)</td>
<td>TS, MS</td>
<td>1200 A, 13.8 kV</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>28</td>
<td>Air Magnetic Breaker (Indoor)</td>
<td>TS, MS</td>
<td>1200 A, 13.8 kV</td>
<td>25</td>
<td>40</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>29</td>
<td>Metal clad/Metal Enclosed Switchgear (Air)</td>
<td>TS, MS</td>
<td>3000 A, 13.8 kV</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>30</td>
<td>Metal clad/Metal Enclosed Switchgear (GIS)</td>
<td>TS, MS</td>
<td>3000 A, 13.8 kV</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>RTM</td>
</tr>
<tr>
<td>31</td>
<td>Station Grounding System</td>
<td>TS, MS</td>
<td>15 ground rods, 100 x 100 foot, 13.8 kV station</td>
<td>25</td>
<td>40</td>
<td>60</td>
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</tr>
<tr>
<td>32</td>
<td>Station Grounding Transformer</td>
<td>TS, MS</td>
<td>13.8 kV, 250A per phase for 1 minute</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>RI</td>
</tr>
<tr>
<td>33</td>
<td>SCADA RTU</td>
<td>TS, MS</td>
<td>Medium station, 13.8 kV, 30 feeders</td>
<td>15</td>
<td>20</td>
<td>30</td>
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<tr>
<td>34</td>
<td>Automatic Transfer Switch</td>
<td>UK</td>
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<td></td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>35</td>
<td>Network Transformer</td>
<td>Network Unit</td>
<td>UK</td>
<td>750 kVA, 120/208 V</td>
<td>20</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>36</td>
<td>Pad Mounted Transformer</td>
<td>Protector Unit</td>
<td>UK</td>
<td>1 PH, 100 kVA, 18 kV</td>
<td>30</td>
<td>40</td>
<td>40</td>
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<tr>
<td>37</td>
<td>Vault Transformer</td>
<td>UK</td>
<td>1 PH, 100 kVA, 18 kV</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>RI</td>
</tr>
<tr>
<td>38</td>
<td>Submersible Transformer</td>
<td>UK</td>
<td>1 PH, 100 kVA, 18 kV</td>
<td>25</td>
<td>35</td>
<td>40</td>
<td>RI</td>
</tr>
</tbody>
</table>

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### 1 Executive Summary

<table>
<thead>
<tr>
<th>Report Section #</th>
<th>Asset Category</th>
<th>Componentization (Sub-category)</th>
<th>Parent*</th>
<th>Typical Asset Size</th>
<th>Useful Life (years)</th>
<th>Maintenance Type**</th>
<th>Time Based Maint Schedule (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>Network Vault</td>
<td>Overall</td>
<td>UG</td>
<td>2.3mW x 6.4mL x 3.4mH (O.D.)</td>
<td>40 60 80</td>
<td>RTM</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td>Roof</td>
<td></td>
<td>2.3mW x 6.4mL</td>
<td>20 25 30</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>Radial Vault</td>
<td>Overall</td>
<td>UG</td>
<td>3.0m W x 8.5m L x 3.65m H (I.D.)</td>
<td>40 60 80</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof</td>
<td></td>
<td>3.0m W x 8.5m L</td>
<td>20 25 30</td>
<td>RTM</td>
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<tr>
<td>41</td>
<td>URD Vault</td>
<td>Overall</td>
<td>UG</td>
<td>1.5m W x 3.5m L x 2.1m H (I.D.)</td>
<td>40 60 80</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof</td>
<td></td>
<td>1.5m W x 3.5m L</td>
<td>20 25 30</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td>42</td>
<td>Submersible Vault</td>
<td>Overall</td>
<td>UG</td>
<td>1.24m W x 2.26m L x 1.86m H (I.D.)</td>
<td>40 60 80</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof</td>
<td></td>
<td>1.24m W x 2.26m L</td>
<td>20 25 30</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td>43</td>
<td>Cable Chamber</td>
<td>Overall</td>
<td>UG</td>
<td>2.5m W x 3.0m L x 2.6m Headroom (L.E.)</td>
<td>50 60 80</td>
<td>RTM</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof</td>
<td></td>
<td>2.5m W x 3.0m L</td>
<td>20 25 30</td>
<td>RTM</td>
<td>3</td>
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<tr>
<td>44</td>
<td>Duct Bank</td>
<td></td>
<td></td>
<td>3W x2H</td>
<td>30 50 80</td>
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<tr>
<td>45</td>
<td>Padmounted Switchgear (SF6/Vacuum)</td>
<td></td>
<td>UG</td>
<td>Not currently in our standard coming soon, VISTA or SF6 Canada power</td>
<td>30 30 60</td>
<td>RI</td>
<td>3</td>
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<tr>
<td>46</td>
<td>Padmounted Switchgear (Air insulated)</td>
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<td>UG</td>
<td>SWITCHGEAR 600A, PADMOUNTED, MANUAL, PMH-H, 28kV stock code #AB10012</td>
<td>20 20 40</td>
<td>RI</td>
<td>3</td>
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<tr>
<td>47</td>
<td>SF6/Vacuum Underground Switch</td>
<td></td>
<td>UG</td>
<td>Leadbreak, Vacuum, SFH, 15kV, 200AMP, 2-WAY 1-SW or 3-WAY 3-SW</td>
<td>30 30 60</td>
<td>RI</td>
<td>3</td>
</tr>
<tr>
<td>48</td>
<td>UG Primary Cable (XLPE in Duct)</td>
<td></td>
<td>UG</td>
<td>1/0 AL 28kV TRXLP EONPEJ, AS PER stock code #71800052</td>
<td>40 40 60</td>
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<td></td>
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<tr>
<td>49</td>
<td>UG Primary Cable (XLPE DB)</td>
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<td>UG</td>
<td>1/0 AL 28kV TRXLP EONPEJ, AS PER stock code #71800052</td>
<td>20 25 25</td>
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<tr>
<td>50</td>
<td>UG Primary Cable (PILC)</td>
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<td>UG</td>
<td>600 KCMIL 3C OU 15kV PILC, AS PER stock code #71800049</td>
<td>70 75 80</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>

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<th>Maintenance Type**</th>
<th>Time Based Maintain Schedule (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>UG Secondary Cable (in Duct)</td>
<td>UG</td>
<td>UG</td>
<td>CABLE 500 KCMIL CU XLPE 600V AS stock code 7150274</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>52</td>
<td>UG Secondary Cable (EJP)</td>
<td>UG</td>
<td>UG</td>
<td>CABLE 500 KCMIL CU XLPE 600V AS stock code 7150274</td>
<td>20</td>
<td>25</td>
<td>25</td>
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<tr>
<td>53</td>
<td>Lighting Assemblies (Conventional)</td>
<td>UG</td>
<td>UG</td>
<td>Net Available</td>
<td>40</td>
<td>40</td>
<td>60</td>
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<tr>
<td></td>
<td></td>
<td>Cabling</td>
<td></td>
<td>Net Available</td>
<td>50</td>
<td>50</td>
<td>60</td>
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<tr>
<td></td>
<td></td>
<td>Civil (handwell, tap box)</td>
<td></td>
<td>Net Available</td>
<td>40</td>
<td>50</td>
<td>60</td>
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<tr>
<td></td>
<td></td>
<td>Pole</td>
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<td>Net Available</td>
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<td>25</td>
<td>30</td>
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<tr>
<td></td>
<td></td>
<td>Luminaire</td>
<td></td>
<td>Net Available</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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2 Wood Pole (Fully Dressed)

The asset referred to in this category is the fully dressed wood pole. This includes the wood pole, crossarms, insulators, and brackets. As wood poles are the most common form of support for medium voltage overhead feeders and low voltage lines, a vast majority of the poles at THESL are wood poles. These poles range in size from 30 to 55 feet, with the typical pole being 40 feet.

The most significant component of this class is the wood pole itself. The wood species predominately used for distribution systems are Red Pine, Jack Pine, and Western Red Cedar (WRC), either butt treated or full length treated. Smaller numbers of Larch, Fir, White Pine and Southern Yellow Pine have also been used. Preservative treatments applied prior to 1980, range from none on some WRC poles, to butt treated and full length Creosote or Pentachlorophenol (PCP) in oil. The present day treatment, regardless of species, is CCA-Peg (Chromated Copper Arsenate, in a Polyethylene Glycol solution). Other treatments such as Copper Naphthenate and Ammoniacal Copper Arsenate have also been used, but these are relatively uncommon.

2.1 Degradation Mechanism
The end of life criteria for wood poles includes loss of strength, functionality, or safety (typically due to rot, decay, or physical damage). As wood is a natural material the degradation processes are somewhat different from those which affect other physical assets on the electricity distribution systems. The critical processes are biological, involving naturally occurring fungi that attack and degrade wood, resulting in decay. The nature and severity of the degradation depends both on the type of wood and the environment. Some fungi attack the external surfaces of the pole and some the internal heartwood. Therefore, the mode of degradation can be split into either external rot or internal rot. As a structural item the sole concern when assessing the condition for a wood pole is the reduction in mechanical strength due to degradation or damage.

2.2 System Hierarchy
Wood poles are considered a part of the Overhead Lines system.

2.3 Useful Life and Typical Life
The useful life of the wood pole component ranges from 40 to 50 years, with a typical value of approximately 44 years [1].

2.4 Time Based Maintenance Intervals
The typical utility routine inspection interval for this asset is every 15 years.
3 Concrete poles

Although a vast majority of the poles at THESL are wood poles, a significant number of concrete poles are also in use. This asset category includes concrete poles, brackets, and insulators. These poles range in size from 30 to 55 feet, with the typical pole being 40 feet.

3.1 Degradation Mechanism
The most significant component in this class is the concrete pole itself. Concrete poles age in the same manner as any other concrete structure. Any moisture ingress inside the concrete pores would result in freezing during the winter and damage to concrete surface. Road salt spray can further accelerate the degradation process and lead to concrete spalling. Typical concrete mixes employ a washed-gravel aggregate and have extremely high resistance to downward compressive stresses (about 3,000 lb/sq in), however, any appreciable stretching or bending (tension) will break the microscopic rigid lattice, resulting in cracking and separation of the concrete. The spun concrete process used in manufacturing poles prevents moisture entrapment inside the pores. Spun, pre-stressed concrete is particularly resistant to corrosion problems common in a water-and-soil environment.

3.2 System Hierarchy
Concrete poles are considered a part of the Overhead Lines system.

3.3 Useful Life and Typical Life
The useful life range of the concrete pole component is 50 to 60 years; the typical life is 60 years [2][3].

3.4 Time Based Maintenance Intervals
For a typical utility, the routine inspection schedule for this asset is every 15 years.
4 Remotely Operated Overhead Switch

This asset class consists of overhead line three-phase, gang operated switches. The primary function of switches is to allow for isolation of line sections or equipment for maintenance, safety or other operating requirements. While some categories of the switches are rated for load interruption, others are designed to operate under no load conditions and operate only when the current through the switch is zero. Most distribution line switches are rated 600 A continuous rating. Switches when used in conjunction with cutout fuses provide short circuit interruption rating. Disconnect switches are sometimes provided with padlocks to allow staff to obtain work permit clearance with the switch handle locked in open position.

In general, line switches consist of mechanically movable copper blades supported on insulators and mounted on metal bases. Since they do not typically need to interrupt short circuit currents, disconnect switches are simple in design relative to circuit breakers.

4.1 Degradation Mechanism

The main degradation processes associated with line switches include:
- Corrosion of steel hardware or operating rod
- Mechanical deterioration of linkages
- Switch blades falling out of alignment
- Loose connections
- Non functioning padlocks
- Insulators damage
- Missing ground connections
- Missing nameplates for proper identification

The rate and severity of these degradation processes depends on a number of interrelated factors including the operating duties and environment in which the equipment is installed. In most cases, corrosion or rust represents a critical degradation process. The rate of deterioration depends heavily on environmental conditions in which the equipment operates. Corrosion typically occurs around the mechanical linkages of these switches. Corrosion can cause seizing. When lubrication dries out, the switch operating mechanism may seize making the disconnect switch inoperable. In addition, when blades fall out of alignment, excessive arcing may result. While a lesser mode of degradation, air pollution also can affect support insulators. Typically, this occurs in heavy industrial areas or where road salt is used.

4.2 System Hierarchy

Overhead switches are considered a part of the Overhead Lines system.

4.3 Useful Life and Typical Life

The useful life of remotely operated switches is in the range of 30 to 50 years; the typical life is 45 years [1].

4.4 Time Based Maintenance Intervals

The typical routine testing/maintenance schedule for this asset is every two years.
5 Manually Operated Overhead Switch

Like the remotely operated overhead switch, the primary function of this asset is to allow for isolation of overhead line sections or equipment for maintenance, safety or other operating requirements. The operating control mechanism can be either a simple hookstick or manual gang. The manually operated switches used by THESL have typical ratings of 28 kV, 600A.

5.1 Degradation Mechanism
Like the remotely operated switch, the main degradation processes associated with manually operated line switches include the following, with rate and severity depending on operating duties and environment:

- Corrosion of steel hardware or operating rod
- Mechanical deterioration of linkages
- Switch blades falling out of alignment
- Loose connections
- Non functioning padlocks
- Insulators damage
- Missing ground connections
- Missing nameplates for proper identification

5.2 System Hierarchy
Overhead switches are considered a part of the Overhead Lines system.

5.3 Useful Life and Typical Life
The useful life of manually operated switches is in the range of 30 to 60 years; the typical life is 50 years [2].

5.4 Time Based Maintenance Intervals
The typical routine testing/maintenance schedule for manually operated overhead switches is two years.
6 SCADAMATE Overhead Switch

SCADAMATE switches are a type of overhead line switches that are can receive signals from and be monitored by the SCADA system. These units include the switch, communications, and RTU. As with other line switches, this asset allows for the isolation of overhead line sections or equipment for maintenance, safety, or other operating requirements. THESL's SCADAMATE switches have typical ratings of 28 kV, 600A.

6.1 Degradation Mechanism
Like the remotely operated switch, the main degradation processes associated with manually operated line switches include the following:

- Corrosion of steel hardware or operating rod
- Mechanical deterioration of linkages
- Switch blades falling out of alignment
- Loose connections
- Non functioning padlocks
- Insulators damage
- Missing ground connections
- Missing nameplates for proper identification

The rate and severity of degradation are a function on operating duties and environment:

6.2 System Hierarchy
Overhead switches are considered a part of the Overhead Lines system.

6.3 Useful Life and Typical Life
The useful life range of SCADAMATE switches is 30 to 50 years; the typical life is 45 years [1][4].

6.4 Time Based Maintenance Intervals
The typical routine testing/maintenance schedule for SCADAMATEs is two years.
7 Overhead Primary Conductor

Electrical current flows through distribution line conductors, facilitating the movement of power throughout the distribution system. These conductors are supported by either metal or wood structures to which they are attached by insulator strings suitable for the voltage at which the conductors operate. The conductors are sized for the amount of current to be carried and other design requirements. The overhead conductors typically used by THESL are Wire 556 ACS (DAHLIA) and Cable 336 ACS 15 kV Tree Proof.

7.1 Degradation Mechanism

To function properly, conductors must retain both their conductive properties and mechanical (i.e. tensile) strength. Aluminum conductors have three primary modes of degradation: corrosion, fatigue and creep. The rate of each degradation mode depends on several factors, including the size and construction of the conductor, as well as environmental and operating conditions. Most utilities find that corrosion and fatigue present the most critical forms of degradation.

Generally, corrosion represents the most critical life-limiting factor for aluminum-based conductors. Visual inspection cannot detect corrosion readily in conductors. Environmental conditions affect degradation rates from corrosion. Both aluminum and zinc-coated steel core conductors are particularly susceptible to corrosion from chlorine-based pollutants, even in low concentrations.

Fatigue degradation presents greater detection and assessment challenges than corrosion degradation. In extreme circumstances, under high tensions or inappropriate vibration control, fatigue can occur in very short timeframes. However, under normal operating conditions, with proper design and application of vibration control, fatigue degradation rates are relatively slow. Under normal circumstances, widespread fatigue degradation is not commonly seen in conductors less than 70 years of age. Also, in many cases detectable indications of fatigue may only exist during the last 10% of a conductor’s life.

In designing transmission lines, engineers ensure that conductors receive no more than 60% of their rated tensile strength (RTS) during heaviest anticipated weather loads. The tensile strength of conductors gradually decreases over time. When conductors experience unexpectedly large mechanical loads and tensions beyond 50% of their RTS, they begin to undergo permanent stretching with noticeable increases in sagging.

Overloading lines beyond their thermal capacity causes elevated operating temperatures. When operating at elevated temperatures, aluminum conductors begin to anneal and lose tensile strength. Each elevated temperature event adds further damage to the conductor. After a loss of 10% of a conductor’s RTS, significant sag occurs, requiring either resagging or replacement of the conductor. Because of their steel cores, Aluminum Conductor Steel Reinforced (ACSR) conductors can withstand greater annealing degradation than Aluminum Stranded Conductor (ASC).

Phase to phase power arcs can result from conductor galloping during severe storm events. This can cause localized burning and melting of a conductor’s aluminum
strands, reducing strength at those sites and potentially leading to conductor failures. Visual inspection readily detects arcing damage.

Other forms of conductor damage include:

- Broken strands (i.e., outer and inners)
- Strand abrasion
- Elongation (i.e., change in sags and tensions)
- Burn damage (i.e., power arc/clashing)
- Birdcaging

### 7.2 System Hierarchy
The overhead conductor asset class is a part of the Overhead Lines system.

### 7.3 Useful Life and Typical Life
The overhead primary conductor are of two types:

- Primary Bare
- Primary Tree Proof

#### 7.3.1 Primary Bare
According to a utility study and Kinectrics experience, the useful life of overhead primary conductors is in the range of 50 to 77 years, with the typical life close to 60 years [5][6].

#### 7.3.2 Primary Tree Proof
According to a utility study and Kinectrics experience, the useful life of overhead primary conductors is in the range of 50 to 77 years, with the typical life close to 60 years [5][6].
8 Overhead Secondary Conductors

Secondary Overhead Conductors are typically used in overhead lines (in circuits not exceeding 600 volt phase to phase) on poles or as feeders to residential premises. The typical secondary overhead conductor used by THESL is the Triplex 2-266.8 AL XLPEI 1–3/0.

8.1 Degradation Mechanism
Overhead secondary conductors have a similar degradation mechanism to primary overhead conductors. These conductors must retain both their conductive properties and mechanical strength. The primary modes of degradation are corrosion, fatigue, and creep. The degree of degradation is a function of conductor size, construction, and environmental and operating conditions.

Additional forms of conductor damage include:

- Broken strands (i.e., outer and inners)
- Strand abrasion
- Elongation (i.e., change in sags and tensions)
- Burn damage (i.e., power arc/clashing)
- Birdcaging

8.2 System Hierarchy
The overhead secondary conductor asset class is a part of the Overhead Lines system.

8.3 Useful Life and Typical Life
According to a utility study and Kinectrics experience, the useful life of secondary overhead conductors is in the range of 50 to 77 years, with the typical life close to 60 years [5][6].
9 Pole Mounted Transformer

Transformers are static devices that perform step-up and step-down voltage change operations. Distribution line transformers change the medium or low distribution voltage to 120/240 V or other common voltages for use in residential and commercial applications. The pole mounted transformers used by THESL range from single phase, 50 kVA, 16 kV to single phase, 167 kVA, 16 kV, with the typical being single phase, 100 kVA, 16 kV.

9.1 Degradation Mechanism

It has been demonstrated that the life of the transformer’s internal insulation is related to temperature-rise and duration. Therefore, transformer life is affected by electrical loading profiles and length of time in service. Other factors such as mechanical damage, exposure to corrosive salts, and voltage and current surges also have a strong effect. Therefore, a combination of condition, age and load based criteria is commonly used to determine the useful remaining life of distribution transformers.

The impacts of loading profiles, load growth, and ambient temperature on asset condition, loss-of-life, and life expectancy can be assessed using methods outlined in ANSI/IEEE Loading Guides. This also provides an initial baseline for the size of transformer that should be selected for a given number and type of customers to obtain optimal life.

9.2 System Hierarchy

The Pole Mounted Transformer asset class is a part of the Overhead Lines system.

9.3 Useful Life and Typical Life

In the Kinectrics study [7], it was found that the useful life of the pole mounted transformer is in the range of 30 to 40 years, with an average value of approximately 40 years.
10 Lighting Assemblies (High Mast)

High mast lighting is typically employed in areas where high and uniform levels of illumination, easy maintenance, and minimum ground level obstruction are required. They are, for example, used in roadways and highways. High-mast towers are constructed from welded tubular sections that taper towards the top. The masts are finished through a hot-dip galvanizing process and are therefore designed to withstand extreme weather conditions. The towers have welded base plates that are bolted to concrete foundations. A ring at the top of the towers holds multiple luminaires.

10.1 Degradation Mechanism

High mast towers are subject to environmental damage. Wind causes fatigue to all parts of the structure, including the anchor bolts and base-plate weld and vertical welds along the height of the structure. Rain, snow, and moisture from condensation result in corrosion, particularly to slip joints and in the vicinity of welded connections. The luminaires used in high mast systems degrade with age, electrical, mechanical, and environmental stresses (wind, heat, cold, etc).

10.2 System Hierarchy

High mast street lighting is a part of the Overhead Lines system.

10.3 Useful Life and Typical Life

The high mast lighting assemblies can be componentized into:

- High Mast Pole
- Cabling
- Luminaires

10.3.1 High Mast Pole

High Mast poles have a useful life range of 60 to 80 years; the typical life is 70 years [8].

10.3.2 Cabling

Cabling has a useful life range of 40 to 60 years; the typical life is 40 years [9][2].

10.3.3 Luminaires

Luminaires have a useful life range of 20 to 30 years; the typical life is 25 years.

10.4 Time Based Maintenance Intervals

The time based routine testing/maintenance interval for all components is every two years.
11 Power Transformer (>10 MVA, >50kV)

While power transformers can be employed in either step-up or step-down mode, a majority of the applications in transmission and distribution stations involve step down of the transmission or sub-transmission voltage to distribution voltage levels. Power transformers vary in capacity and ratings over a broad range. There are two general classifications of power transformers: transmission station transformers and distribution station transformers. For transformer stations, when step down from 230kV or 115kV to distribution voltage is required, ratings may range from 30MVA to 125 MVA. The typical TS power transformer used by THESL is rated as follow: 75/100/125MVA, 230kV/28kV.

11.1 Degradation Mechanism

Transformers operate under many extreme conditions, and both normal and abnormal conditions affect their aging and breakdown. They are subject to thermal, electrical, and mechanical aging. Overloads cause above-normal temperatures, through-faults can cause displacement of coils and insulation, and lightning and switching surges can cause internal localized over-voltages.

For a majority of transformers, end of life is a result of the failure of insulation, more specifically, the failure of pressboard and paper insulation. While the insulating oil can be treated or changed, it is not practical to change the paper and pressboard insulation. The condition and degradation of the insulating oil, however, plays a significant role in aging and deterioration of the transformer, as it directly influences the speed of degradation of the paper insulation. The degradation of oil and paper in transformers is essentially an oxidation process. The three important factors that impact the rate of oxidation of oil and paper insulation are the presence of oxygen, high temperature, and moisture. Particles and acids, as well as static electricity in oil cooled units, also affect the insulation.

Tap changers and bushing are major components of the power transformer. Tap changers are complex mechanical devices and are therefore prone to failure resulting from either mechanical or electrical degradation. Bushings are subject to aging from both electrical and thermal stresses.

11.2 System Hierarchy

Power transformers rated greater than 10MVA, 50 kV are considered a part of the Transmission Station system.

11.3 Useful Life and Typical Life

The overall useful life range of a power transformer at a transmission station is 32 to 55 years; the average life is 45 years.

This asset also has several major components, each of which has a different useful life. These are the transformer core, windings, insulating oil, bushings, and on-load tap changer. From a maintenance practice perspective, a power transformer can be componentized into the following:
11 Power Transformer (>10 MVA, >50kV)

- Winding system (including core, winding, and insulation oil)
- Bushing
- Tap Changer

11.3.1 Winding System
The useful life of the winding system can be in the range of 32-55 years [1], depending on the loading condition and ambient operating temperature, and routine maintenance practices. A typical life of 45 years can be expected for the winding system [11].

11.3.2 Bushings
According to research statistics, the useful life range of bushings is 12-20 years, with a typical life of 15 years [12].

11.3.3 Tap Changer
The useful life range of the tap changer is 20-30 years; the typical life is 30 years [13][14].

11.4 Time Based Maintenance Intervals
For TS power transformers, the typical routine testing/maintenance interval is two years.
12 230 kV Steel Structures & Overhead Bus Work

There are a number of different types of structures at distribution stations for supporting buses and equipment. The predominant types are galvanized steel, either lattice or hollow sections.

12.1 Degradation Mechanism

Degradation or reduction in strength of steel structures can result from corrosion, structural fatigue, or gradual deterioration of foundation components.

Corrosion of lattice steel members and hardware reduces their cross-sectional area causing a reduction in strength. Similarly, corrosion of tubular steel poles reduces the effectiveness of the tubular walls. Rates of corrosion may vary, depending upon environmental and climatic conditions (e.g., the presence of salt spray in coastal areas or heavy industrial pollution).

Structural fatigue results from repeated structural loading and unloading of support members. Temperature variations, plus wind and ice loadings lead to changes in conductor tension. Tension changes result in structural load variations on angle and dead end towers. Other changes such as foundation displacements and breaks in wires, guys and anchors may result in abnormal tower loading.

Typically, steel pole foundations are cylindrical steel reinforced concrete structures with anchor bolts connecting the pole to its base. Common degradation processes include corrosion of foundation rebar, concrete spalling and storm damage.

Busbar degradation is mainly caused by thermal and mechanical stresses.

12.2 System Hierarchy

230 kV Steel Structures and Overhead Bus Work belong to the Transmission Station system.

12.3 Useful Life and Typical Life

This asset group can be componentized into the following:

- 230 kV Steel Structures
- 230 kV Overhead Busbars

12.3.1 230 kV Steel Structures

Based on statistical information from CIGRE, the useful life of steel towers is in the range of 35 to 100 years [1]. The corrosion and structural fatigue that a structure experiences is influenced by the unique combination of environment and weather that it is subject to. As structures at different locations are exposed to varying environments, there is a wide useful life range for this asset component. Normally, a galvanized / painted steel tower has a life expectancy of 50 years [15][16].
12.3.2 230 kV Overhead Busbars
The useful life range of busbars is 30 to 60 years. According to the Kinectrics study [2], the typical life of high voltage overhead busbars is approximately 60 years.
13 Outdoor Station Disconnect Switch (230 kV)

This asset class consists of the 230 kV disconnect switches used to physically and electrically isolate sections of the power transmission system for the purposes of maintenance, safety, and other operational requirements. Outdoor air-insulated disconnect switches typically consist of manual or motor operated isolating devices mounted on support insulators and metal support structures. Many high voltage disconnect switches (e.g. line and transformer isolating switches) have motor-operators and the capability of remote-controlled operation. These switches are normally operated when there is no current through the switch, unless specifically designed to be capable of operating under load.

13.1 Degradation Mechanism

Disconnect switches have many moving parts that are subject to wear and operational stress. Except for parts contained in motor-operator cabinets, switch components are exposed to the ambient environment. Thus, environmental factors, along with operating conditions, vintage, design, and configuration all contribute to switch degradation. Critical degradation processes include corrosion, moisture ingress, and ice formation. A combination of these factors that may result in permanent damage to major components such as contacts, blades, bearings, drives and support insulators.

Generally, the following represent key end-of-life factors for disconnect switches:

- Decreasing reliability, availability, and maintainability
- High maintenance and operating costs
- Maintenance overhaul requirements
- Obsolete design, lack of parts and service support
- Switch age

Application criticality and manufacturer also play key roles in determining the end-of-life for disconnect switches. Generally, absent a major burnout, widespread deterioration of live components, support insulators, motor-operators, and drive linkages define the end-of-life for these switches. However, routine maintenance programs usually provide ample opportunity to assess switch condition and viability.

Disconnect switches have components fabricated from dissimilar materials, and use of these different materials influences degradation. For example, blade, hinge and jaw contacts may consist of combinations of copper, aluminum, silver and stainless steel, several of which have tin, silver and chrome plating. Further switch bases may consist of galvanized steel or aluminum.

Most disconnect switches have porcelain support and rotating insulators. The porcelain offers rigidity, strength and dielectric characteristics needed for reliability. However, excessive deflection or deformation of support or rotating stack insulators can cause blade misalignment and other problems, resulting in operational failures.

Disconnect switches must have the ability to open and close properly even with heavy ice build-up on their blades and contacts. However, these switches may sit idle for several months or more. This infrequent operation may lead to corrosion and water
ingress damage, increasing the potential for component seizures. Bearings commonly seize from poor lubrication and sealing, despite manufacturers’ claims that such components are sealed, greaseless and maintenance-free for life.

Normally, when blades enter or leave jaw contacts, they rotate to clean accumulated ice from contact surfaces. To accomplish this, hinge ends have rotating or other current transfer contacts. These contacts are often simple, long-life copper braids. However, some switches have more complex rotating contacts in grease-filled chambers. Without proper maintenance these more complex switches may degrade, causing blade failures.

13.2 System Hierarchy
The 230 kV station disconnect switch is a part of the Transmission Station system.

13.3 Useful Life and Typical Life
This asset has a useful life range of 30 to 50 years; the typical life is 45 years [1].

13.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset is every 5-8 years. Utilities will typically increase diagnostic testing to justify the increase of maintenance intervals.
14 Transmission Station (TS) AC Station Service

The AC station service is the supply system that provides power to the auxiliary equipment, such as fans, pumps, heating, or lighting, in the transmission station. The most reliable source of such power is directly from the transmission or distribution lines. Small power transformers are configured to provide this requirement. In addition to the transformer, low voltage (LV) switchgear is another major component of the AC station service. The transformer typically used by THESL is rated at 300 kVA; the switchgear rating is 1600A.

14.1 Degradation Mechanism

The degradation of the TS AC station service is closely related to the degradation of the switchgear and transformer. Switchgear degradation is a function of a number of different factors, such as the condition of mechanical mechanisms and interlocks, degradation of solid insulation, and general degradation/corrosion. In most cases end of life is related to non-conditional issues, such as capability, obsolescence, or specific/generic defects.

For a majority of transformers, end of life is a result of insulation failure. Oil and paper insulation degrade because of oxidation, and factors that impact the rate of oxidation are the presence of oxygen, high temperature, and moisture. Particles and acids, as well as static electricity in oil cooled units, also affect the insulation.

14.2 System Hierarchy

The TS AC station service class is a part of the Transmission Station system.

14.3 Useful Life and Typical Life

TS AC Station Service can be componentized into the following:

- Transformer
- LV Switchgear

14.3.1 Transformer

The station service transformer has a useful life range of 32 to 55 years; the typical life is 45 years [1][11].

14.3.2 LV Switchgear

The station service LV switchgear has a useful life range of 40 to 60 years. The typical life is 40 years [1].

14.4 Time Based Maintenance Intervals

This asset class has a routine testing/maintenance interval of three years.
15 Power Transformer (>2.5MVA and <10MVA), <50kV)

Power transformers at distribution stations typically step down voltage to distribution levels. Ratings typically range from 5 MVA to 30 MVA. The typical distribution transformers used by THESL are rated as follows: 5/6.7MVA, 27.6/4kV.

15.1 Degradation Mechanism
The degradation of the power transformers at municipal stations or at customer sites is similar to that of the transformers at transmission stations. These transformers are subject to electrical, thermal, and mechanical aging. Degradation of the insulating oil, and more significantly, paper insulation, typically results in end of life. Insulation degradation is a result of oxidation, a process that occurs in the presence of oxygen, high temperature, and moisture. For oil cooled transformers, particles, acids, and static electricity will also deteriorate the insulation.

Tap changers and bushing are major components of the power transformer. Tap changers are prone to failure resulting from either mechanical or electrical degradation. Bushings are subject to aging from both electrical and thermal stresses.

15.2 System Hierarchy
These power transformers are a part of the Municipal Station system.

15.3 Useful Life and Typical Life
The useful life of power transformers rated between 2.5 MVA and 10 MVA is 32 to 55 years; the typical life is 45 years.

The power transformer also has major components that have different useful lives. Componentization is as follows:

- Winding
- Bushing
- Tap Changer

15.3.1 Winding
The useful life of windings is 32 to 55 years; the typical life is 45 years [1][11].

15.3.2 Bushings
The useful life of bushings is 12 to 20 years; the typical life is 15 years [12].

15.3.3 Tap Changer
The useful life range of the tap changer is 20 to 30 years; the typical life is 30 years [13][14].

15.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for these transformers is two years.
16 Station Steel Structures & Overhead Bus Work (<50kV)

There are a number of different types of structures at distribution stations for supporting buses and equipment. The predominant types are galvanized steel, either lattice or hollow sections. A typical unit of this asset class is a bus structure for 27.6 kV/4KV for two of 5 MV transformers.

16.1 Degradation Mechanism
Degradation of this asset class is similar to the degradation of steel structure and overhead bus work for 230 kV. Reduction in steel strength is a result of corrosion, structural fatigue, or deterioration of foundation components. Corrosion, which can be accelerated by environmental condition, affects lattice steel members and tubular steel walls. Structural fatigue results from wind or ice loading and unloading of support members. Concrete foundations are also subject to deterioration.

16.2 System Hierarchy
Station steel structures and overhead bus work (<50kV) are a part of the Municipal Station system.

16.3 Useful Life and Typical Life
Based on statistical information from CIGRE, the useful life of steel towers is in the range of 35 to 100 years [1]. The corrosion and structural fatigue that a structure experiences is influenced by the unique combination of environment and weather that it is subject to. As structures at different locations are exposed to varying environments, there is a wide useful life range for this asset component. Normally, a galvanized/painted steel tower has a life expectancy of 50 years [15][16].
17 Outdoor Station Disconnect Switch (<50kV)

Under normal operating conditions, disconnect switches isolate various other equipment from system voltages. Outdoor air-insulated disconnect switches typically consist of manual or motor operated isolating devices mounted on support insulators and metal support structures. These switches are normally operated when there is no current through the switch, unless specifically designed to be capable of operating under load. The typical disconnect switch (rated below 50 kV) used by THESL are rated 600A, 27.6kV.

17.1 Degradation Mechanism
The outdoor disconnect switch rated below 50 kV has a similar degradation process to that of the disconnect switch rated at 230 kV. These switches, having many moving parts, are subject to wear and operational stress. The components that are outside of the motor operating cabinets are also exposed to the environment.

Environmental factors, operating condition, vintage, design, and configuration contribute to switch degradation. Corrosion, moisture ingress, and ice formation can cause damage or misalignments to major components. The following represent key end-of-life factors for disconnect switches:

- Decreasing reliability, availability, and maintainability
- High maintenance and operating costs
- Maintenance overhaul requirements
- Obsolete design, lack of parts and service support
- Switch age

17.2 System Hierarchy
Outdoor station disconnect switches rated below 50 kV are a part of the Municipal Station system.

17.3 Useful Life and Typical Life
The useful life range of this asset is 30 to 50 years; the typical life is 45 years [1].

17.4 Time Based Maintenance Intervals
Disconnect switches are subject to routine testing/maintenance every 5 to 8 years. Utilities will increase the intervals based on the frequency of interim diagnostic testing.
18 Municipal Station (MS) AC Station Service

The AC station service is the supply system that provides power to the auxiliary equipment, such as fans, pumps, heating, or lighting, in the distribution station. The most reliable source of such power is directly from the transmission or distribution lines. Small power transformers are configured to provide this requirement. The transformer typically used in THESL’s MS AC station service is rated at 75 kVA.

18.1 Degradation Mechanism
Degradation of the MS AC station service is related to the end of life of the transformer. As with most transformers, end of life is typically a result of insulation failure, particularly paper insulation. The oil and paper insulation degrade as oxidation takes place in the presence of oxygen, high temperature, and moisture. Acids, particles, and static electricity also have degrading effects to the insulation.

18.2 System Hierarchy
The MS AC Station service is a part of the Municipal Station system.

18.3 Useful Life and Typical Life
This asset can be componentized into the following:
- Transformer
- AC Panel

18.3.1 Transformer
The transformer component has a useful life range of 32 to 55 years; the typical life is 45 years [1][1].

18.3.2 AC Panel
The AC Panel component has a useful life range of 40 to 60 years; the typical life is 40 years [2].

18.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset is three years.
19 DC Station Services

The DC station service asset class includes battery banks and chargers. Equipment within transmission and municipal stations must be provided with a guaranteed source of power to ensure they can be operated under all system conditions, particularly during fault conditions. There is no known way to store AC power so the only guaranteed instantaneous power source must be DC, based on batteries.

19.1 Degradation Mechanism

Effective battery life tends to be much shorter than many of the major components in a station. The deterioration of a battery from an apparently healthy condition to a functional failure can be rapid. This makes condition assessment very difficult. However, careful inspection and testing of individual cells often enables the identification of high risk units in the short term.

It is well understood in the utility industry that regular inspection and maintenance of batteries and battery chargers is necessary. In most cases the explicit reason for carrying out regular maintenance inspection is to detect minor defects and rectify them. However, critical examination of trends in maintenance records can give an early warning of potential failures.

Despite the regular and frequent maintenance and inspection of battery systems, failures in service are still relatively frequent. For this reason, many utilities employ battery monitors and alarm systems. The earlier versions of these are still widely used and are relatively unsophisticated devices that measure basic battery parameters with pre-set alarm levels. More modern monitoring devices have the ability to identify a potential failure as it develops and to provide a warning.

Although battery deterioration is difficult to detect, any changes in the electrical characteristics or observation of significant internal damage can be used as sensitive measures of impending failure. Batteries consist of multiple individual cells. While the significant deterioration/failure of an individual cell may be an isolated incident, detection of deterioration in a number of cells in a battery is usually the precursor to widespread failure and functional failure of the total battery.

Battery chargers are also critical to the satisfactory performance of the whole battery system. Battery chargers are relatively simple electronic devices that have a high degree of reliability and a significantly longer lifetime than the batteries themselves. Nevertheless, problems do occur. As with other electronic devices, it is difficult to detect deterioration prior to failure. It is normal practice during the regular maintenance and inspection process to check the functionality of the battery chargers, in particular the charging rates. Where any functional failures are detected it would be normal to replace the battery charger.

19.2 System Hierarchy

DC station services belong to both Transmission and Municipal Station systems.
19.3 Useful Life and Typical Life
The overall useful life of the DC station service is 10 to 30 years, with a typical life of 20 years.

This asset also has two major components that have differing useful lives:

- Battery Banks
- Charger

19.3.1 Battery Bank
The battery bank has a useful life range of 10 to 30 years; typical life is 20 years [2][17].

19.3.2 Charger
The charger has a useful life range of 20 to 30 years; typical life is 20 years [18][19].

19.4 Time Based Maintenance Intervals
Typically, routine testing/maintenance for batteries is conducted annually. The maintenance of schedule battery chargers is typically coordinated that of the battery.
20 Indoor Station Disconnect Switch (<50kV)

Under normal operating conditions, disconnect switches isolate various other equipment from system voltages. The typical indoor disconnect switch (rated below 50 kV) used by THESL are rated 600A Gang, LBS, 4 kV.

20.1 Degradation Mechanism
Like other types of switches, this asset, having many moving parts, is subject to wear and operational stress. The following represent key end-of-life factors for disconnect switches:

- Decreasing reliability, availability, and maintainability
- High maintenance and operating costs
- Maintenance overhaul requirements
- Obsolete design, lack of parts and service support
- Switch age

20.2 System Hierarchy
Indoor station disconnect switches rated below 50 kV are a part of the Transmission and Municipal Station system.

20.3 Useful Life and Typical Life
The useful life range of this asset is 30 to 50 years; the typical life is 45 years [1].

20.4 Time Based Maintenance Intervals
Disconnect switches are subject to routine testing/maintenance every 5 to 8 years. Utilities will increase the intervals based on the frequency of interim diagnostic testing.
21 Oil Circuit Breaker (Outdoor)

Circuit breakers are automated switching devices that can make, carry and interrupt electrical currents under normal and abnormal conditions. Circuit breakers at THESL are commonly used at transmission or distribution stations for switching 27.6, 13.8 or 4.16 kV feeders. Breakers are required to operate infrequently, however, when an electrical fault occurs, breakers must operate reliably and with adequate speed to minimize damage.

The oil circuit breakers (OCB) which represent the oldest type of breaker design, have been in use for over 70 years. Two types of designs exist among OCBs: bulk oil breakers (in which oil serves as the insulating and arc quenching medium) and minimum oil breakers (in which oil provides the arc quenching function only). The typical outdoor breaker used by THESL is rated 1200A, 13.8 kV.

21.1 Degradation Mechanism

The key degradation processes associated with OCBs are as follows:

- Corrosion
- Effects of moisture
- Mechanical
- Bushing deterioration

The rate and severity of these degradation processes is dependent on a number of interrelated factors, in particular the operating duties and environment in which the equipment is installed. Often the critical degradation process is either corrosion or moisture ingress or a combination of the two, resulting in degradation to internal insulation, deterioration of the mechanism affecting the critical performance of the breaker, damage to major components such as bushings or widespread degradation to oil seals and structurally components.

Recent international experience indicates that a significant area of concern is barrier-bushing deterioration resulting from moisture ingress. The Synthetic Resin Bonded Paper (SRBP) insulation absorbs the moisture, which can result in discharge tracking across its surface leading to eventual failure of the bushing. Oil impregnated paper bushings are particularly sensitive to moisture. Once moisture finds its way into the oil and then into the paper insulation, it is very difficult to remove and can eventually lead to failure. Significant levels of moisture in the main tank can lead to general degradation of internal components and in acute cases free water can collect at the bottom of the tank. This creates a condition where a catastrophic failure could occur during operation.

Corrosion of the main tank and other structural components is also a concern. One area that is particularly susceptible to corrosion is underneath the main tank on the “bell end”, this problem is common to both single and three tank circuit breakers.

Corrosion of the mechanical linkages associated with the OCB operating mechanism is also a widespread problem that can lead to the eventual seizure of the links.
A lesser mode of degradation, although still serious in certain circumstances, is pollution of bushings, particularly where the equipment is located by the sea or in a heavy industrial area.

Other areas of degradation include:

- Deterioration of contacts
- Wear of mechanical components such as bearings
- Loose primary connections
- Deterioration of concrete plinth affecting stability of the circuit breaker

21.2 System Hierarchy
Oil circuit breakers are used in both Transmission and Municipal Station systems.

21.3 Useful Life and Typical Life
The typical life range of the oil breaker asset class is 30 to 60 years; the typical life is 42 years [1][2].

21.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for oil breakers is three years.
22 SF6 Circuit Breaker (Outdoor)

The typical outdoor SF6 breaker used by THESL is rated at 2500A, 13.8 kV or 1200A, 27.6 kV.

Sulfur hexafluoride (SF6) insulated equipment is a relatively young technology. The first SF6 equipment was developed in the late 1960s. After some initial design and manufacturing problems equipment was increasingly used to replace oil filled equipment with widespread adoption and utilization since the mid 1980s. One of the more remarkable features of SF6 is its performance when subjected to an arc, or during a fault operation. SF6 is extremely stable and even at the high temperatures associated with an arc, limited breakdown occurs. Furthermore, most of the products of the breakdown recombine to form SF6. Consequently, SF6 circuit breakers can operate under fault conditions many more times than oil breakers before requiring maintenance.

22.1 Degradation Mechanism
Failures relating to internal degradation and ultimate breakdown of insulation are limited to early life failures where design or manufacture led to specific problems. There is virtually no experience of failures resulting from long term degradation within the SF6 chambers. Failures and incorrect operations are primarily related to gas leaks and problems with the mechanism and other ancillary systems. Gas seals and valves are a potential weak point. Clearly, loss of SF6 or ingress of moisture and air compromise the performance of the breaker. As would be expected the earlier SF6 equipment was more prone to these problems. Seals and valves have progressively been improved in more modern equipment.

Many of the earlier breakers relied on hydraulic or pneumatic assisted mechanisms. These have proved problematic in some cases and contributed significantly to the higher failure rates associated with this generation of equipment. More recent equipment usually utilize spring assisted mechanisms that have proved more reliable and require less maintenance.

22.2 System Hierarchy
SF6 circuit breakers are used in both Transmission and Municipal Station systems.

22.3 Useful Life and Typical Life
The typical life range of the SF6 breaker is 30 to 60 years; typical life is 42 years [1][2].

22.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for SF6 breakers is three years.
23 Vacuum Circuit Breaker (Outdoor)

The typical outdoor vacuum breakers used by THESL are rated 3000A, 13.8 kV or 1200A, 27.6 kV.

Vacuum Breakers consist of fixed and moving butt type contacts in small evacuated chambers (i.e. bottles). A bellows attached to the moving contact permits the required short stroke to occur with no vacuum losses. Arc interruption occurs at current zero after withdrawal of the moving contact. Current medium voltage vacuum breakers require low mechanical drive energy, have high endurance, can interrupt fully rated short circuits up to 100 times, and operate reliably over 30,000 or more switching operations. Vacuum breakers also are safe and protective of the environment.

23.1 Degradation Mechanism

Circuit breakers have many moving parts that are subject to wear and stress. They frequently “make” and “break” high currents and experience the arcing accompanying these operations. All circuit breakers undergo some contact degradation every time they open to interrupt an arc. Also, arcing produces heat and decomposition products that degrade surrounding insulation materials, nozzles, and interrupter chambers. The mechanical energy needed for the high contact velocities of these assets adds mechanical deterioration to their degradation processes.

The rate and severity of degradation depends on many factors, including insulating and conducting materials, operating environments, and a breaker’s specific duties. The International Council on Large Electric Systems’ (CIGRE) have identified the following factors that lead to end-of-life for this asset class:

- Decreasing reliability, availability and maintainability
- High maintenance and operating costs
- Changes in operating conditions, rendering the existing asset obsolete
- Maintenance overhaul requirements
- Circuit breaker age

Outdoor circuit breakers may experience adverse environmental conditions that influence their rate and severity of degradation. For outdoor mounted circuit breakers, the following represent additional degradation factors:

- Corrosion
- Effects of moisture
- Bushing/insulator deterioration
- Mechanical

Corrosion and moisture commonly cause degradation of internal insulation, breaker performance mechanisms, and major components like bushings, structural components, and oil seals. Corrosion presents problems for almost all circuit breakers, irrespective of their location or housing material. Rates of corrosion degradation, however, vary depending on exposure to environmental elements. Underside tank corrosion causes problem in many types of breakers, particularly those with steel tanks. Another widespread problem involves corrosion of operating mechanism linkages that result in
eventual link seizures. Corrosion also causes damage to metal flanges, bushing hardware and support insulators.

Moisture causes degradation of the insulating system. Outdoor circuit breakers experience moisture ingress through defective seals, gaskets, pressure relief and venting devices. Moisture in the interrupter tank can lead to general degradation of internal components. Also, sometimes free water collects in tank bottoms, creating potential catastrophic failure conditions.

For circuit breakers, mechanical degradation presents greater end-of-life concerns than electrical degradation. Generally, operating mechanisms, bearings, linkages, and drive rods represent components that experience most mechanical degradation problems. Oil leakage also occurs. Contacts, nozzles, and highly stressed components can also experience electrical-related degradation and deterioration. Other defects that arise with aging include:

- Loose primary and grounding connections
- Oil contamination and/or leakage
- Deterioration of concrete foundation affecting stability of breakers

### 23.2 System Hierarchy
Vacuum circuit breakers are used in both Transmission and Municipal Station systems.

### 23.3 Useful Life and Typical Life
The typical useful life range of the vacuum breaker is 30 to 60 years; the typical life is 40 years [2][20].

### 23.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for vacuum breakers is three years.
24 Oil Circuit Breaker (Indoor)

In addition to outdoor installations, oil circuit breakers can be found within metal-cald switchgear. The typical oil breaker used by THESL is rated 1200A, 13.8 kV.

24.1 Degradation Mechanism
This type of circuit breaker has the same degradation mechanism as the outdoor oil breaker. Degradation processes are as follows:

- Corrosion
- Effects of moisture
- Mechanical
- Bushing deterioration

The rate and severity of these degradation processes are dependent on a number of factors, such as operating duties and environment.

24.2 System Hierarchy
Oil circuit breakers are used in both Transmission and Municipal Station systems.

24.3 Useful Life and Typical Life
The typical life range of the oil breaker asset class is 30 to 60 years; the typical life is 42 years [1][2].

24.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for oil breakers is three years.
25 SF6 Circuit Breaker (Indoor)

In addition to outdoor installations, SF6 circuit breakers can be found within metalclad switchgear. The typical indoor SF6 breaker used by THESL is rated at 1200A, 13.8 kV.

25.1 Degradation Mechanism
An indoor SF6 breaker within switchgear has a similar failure mode as an SF6 breaker installed outdoors. Failures are typically attributed to early life failure, as opposed to long term degradation. Failure and mal-operation are primarily attributed to gas leaks and problems with the mechanism.

25.2 System Hierarchy
SF6 circuit breakers are used in both Transmission and Municipal Station systems.

25.3 Useful Life and Typical Life
The typical life range of the SF6 breaker is 30 to 60 years; typical life is 42 years [1][2].

25.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for SF6 breakers is three years.
26 Vacuum Circuit Breaker (Indoor)

In addition to outdoor installations, vacuum circuit breakers can be found within metalclad switchgear. The typical indoor vacuum breakers used by THESL are rated 1250A, 13.8 kV.

26.1 Degradation Mechanism
The vacuum breakers in this asset class have a similar degradation mechanism to outdoor vacuum breakers, where corrosion, moisture, bushing/insulator deterioration, and mechanical degradation are factors.

26.2 System Hierarchy
Vacuum breakers are used in both the Transmission and Municipal Station systems.

26.3 Useful Life and Typical Life
The typical useful life range of the vacuum breaker is 30 to 60 years; the typical life is 40 years [2][20].

26.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
27 Air Blast Circuit Breaker (Indoor)

Air-blast breakers use compressed air as the quenching, insulating and actuating medium. In normal operation, a blast of compressed air carries the arc into an arc chute where it is quickly extinguished. A combination cooler-muffler is often provided to cool ionized exhaust gases before they pass out into the atmosphere and to reduce noise during operation. The typical air blast breakers used by THESL are rated 1200A, 13.8 kV.

27.1 Degradation Mechanism

The air blast circuit breaker has a similar degradation to other types of circuit breakers. The key degradation processes associated with air blast circuit breakers are:

- Corrosion
- Effects of moisture
- Bushing/insulator deterioration
- Mechanical

Severity and rate are dependent on factors such as operating duty and environment. Corrosion is a problem for most types of breakers. It can degrade internal insulators, performance mechanisms, major components (e.g. bushings), structural components, and oil seals. Moisture causes degradation of the insulating system. Mechanical degradation presents greater end-of-life concerns than electrical degradation. Generally, operating mechanisms, bearings, linkages, and drive rods represent components that experience most mechanical degradation problems. Contacts, nozzles, and highly stressed components can also experience electrical-related degradation and deterioration. Other defects that arise with aging include:

- Loose primary and grounding connections
- Oil contamination and/or leakage
- Deterioration of concrete foundation affecting stability of breakers

27.2 System Hierarchy

Air blast breakers are used in both Transmission and Municipal Station systems.

27.3 Useful Life and Typical Life

The typical useful life range of the air blast breaker is 30 to 50 years; the typical life is 40 years [1].

27.4 Time Based Maintenance Intervals

The typical routine testing/maintenance interval for air blast breakers is three years.
28 Air Magnetic Circuit Breaker (Indoor)

In air magnetic circuit breakers, magnetic blowout coils are used to create a strong magnetic field that draws the arc into specially designed arc chutes. The breaker current flows through the blowout coils and produces a magnetic flux. This magnetic field drives the arc against barriers built perpendicular to the length of the arc. The cross sectional area of the arc is thereby reduced, and its resistance is considerably increased. The surface of the barriers cool and de-ionize the arc, thus collaborating to extinguish the arc.

28.1 Degradation Mechanism
Air magnetic breakers have a similar degradation mechanism to other breakers in that corrosion, moisture, bushing/insulator deterioration, and mechanical degradation are factors.

28.2 System Hierarchy
Air magnetic circuit breakers are used in both Transmission and Municipal Station systems.

28.3 Useful Life and Typical Life
The typical useful life range of the air magnetic breaker is 25 to 60 years; the typical life is 40 years [34].

28.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for air magnetic breakers is three years.
29 Metalclad / Metal Enclosed Switchgear (Air)

Metalclad Switchgear consists of an assembly of retractable/racked switchgear devices that are totally enclosed in a metal envelope (metal-enclosed). These devices operate in the medium voltage range, from 4.16 to 36 kV. The typical units used at THESL are rated at 3000A, 13.8 kV. The switchgear includes breakers, disconnect switches, or fusegear, current transformers (CTs), voltage transformers (VTs) and occasionally some or all of the following: metering, protective relays, internal DC and AC power, battery charger(s), and AC station service transformation. The gear is modular in that each breaker is enclosed in its own metal envelope (cell). The gear also is compartmentalized with separate compartments for breakers, control, incoming/outgoing cables or bus duct, and bus-bars associated with each cell.

29.1 Degradation Mechanism

Medium voltage metalclad switchgear is an integral part of all distribution and transmission systems. Switchgear degradation is a function of a number of different factors: mechanism operation and performance, degradation of solid insulation, general degradation/corrosion, environmental factors, or post fault maintenance (condition of contacts and arc control devices). Degradation of the breaker used is also a factor.

Correct operation of the mechanism is critical in devices that make or break fault currents, i.e. the contact opening and closing characteristics must be within specified limits. The greatest cause of mal-operation of switchgear is related to mechanism malfunction. Deterioration due to corrosion or wear due to lubrication failure may compromise mechanism performance by either preventing or slowing down the operation of the breaker. This is a serious issue for all types of switchgear.

In older air filled equipment, degradation of active solid insulation (for example drive links) has been a significant problem for some types of switchgear. Some of the materials used in this equipment, particularly those manufactured using cellulose-based materials (pressboard, SRBP, laminated wood) are susceptible to moisture absorption. This results in a degradation of their dielectric properties that can result in thermal runaway or dielectric breakdown. An increasingly significant area of solid insulation degradation relates to the use of more modern polymeric insulation. Polymeric materials, which are now widely used in switchgear, are very susceptible to discharge damage. These electrical stresses must be controlled to prevent any discharge activity in the vicinity of polymeric material. Failures of relatively new switchgear due to discharge damage and breakdown of polymeric insulation have been relatively common over the past 15 years.

Temperature, humidity and air pollution are also significant degradation factors, so indoor units tend to have better long-term performance. The safe and efficient operation of switchgear and its longevity may all be significantly compromised if the substation environment is not adequately controlled. In addition, the air switchgear can tolerate less number of full fault operations before maintenance is required.

29.2 System Hierarchy

Metalclad switchgear are used in both the Transmission and Municipal Station systems.
29.3 Useful Life and Typical Life
The useful life range of air insulated metalclad/metal enclosed switchgear is 40 to 60 years; the typical life is 50 years [2].

29.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is 6 years.
30 Metalclad / Metal Enclosed Switchgear (GIS)

The latest design of metalclad gear is the Gas Insulated Switchgear (GIS), which uses low-pressure SF6 gas as a general insulation medium, as a replacement for the air. The insulation within the metal enclosure is not necessarily the same as the working fluid in the breakers themselves, which presently is either SF6 or vacuum. The typical units used by THESL are rated 300A, 13.8 kV.

30.1 Degradation Mechanism

Switchgear degradation is a function of a number of different factors: mechanism operation and performance, degradation of solid insulation, general degradation/corrosion, environmental factors, or post fault maintenance (condition of contacts and arc control devices).

The mechanism must operate correctly in devices that break charges, loads and fault currents. Generally, mechanism malfunction causes most operational problems in GIS. Corrosion and lubrication failure may compromise mechanism performance by preventing or slowing its operation.

Solid insulation such as that in entrance bushings, internal support insulators, plus breaker and switch operating rods have caused many GIS failures. Manufacturing, shipping, installing, maintaining and operating the GIS can cause defects in the insulation. Defects include voids in epoxy insulators, delamination of epoxy and metallic hardware, and protrusions on conductors. In floating components, fixed and moving particles can lead to failures. Partial discharge (PD) activity usually leads to flashovers.

Corrosion and general deterioration increase risks of moisture ingress and SF6 leaks, particularly in outdoor GIS. If not treated, these factors may cause the end-of-life for GIS.

GIS is designed and manufactured for outdoor use, but it generally has better long-term performance when installed indoors. Outdoor GIS, particularly older ITE designs, have higher than acceptable SF6 gas leaks because of the poor quality of fittings, connectors, valves, by-pass piping, general enclosure porosity and flange corrosion. Indoor installations reduce problems from corrosion, moisture ingress, low ambient temperatures and SF6 leaks.

GIS have more costly, difficult and time-consuming post fault maintenance requirements than air insulated switchgear. Older GIS have even more post-fault maintenance problems. Accessibility, fault location, fault level and duration, degree of compartmentalization, isolation requirements, pressure relief, burn-through protection, parts and service capabilities all help determine post-fault maintenance needs.

30.2 System Hierarchy

Metalclad Switchgear are used in both the Transmission and Municipal Station systems.
30.3 Useful Life and Typical Life
The useful life range of GIS insulated metalclad/metal enclosed switchgear is 40 to 60 years; the typical life is 50 years [2].

30.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is 6 years.
31 Station Grounding System

Grounding systems in stations dissipate maximum ground fault currents without interfering with power system operation or causing voltages dangerous to people or equipment. Safety hazards from inadequate grounding include excessive ground potential rises and excessive step and touch potentials. Generally, grounding system assets provide suitable paths for ground currents to follow from power equipment and conductors into the earth. Consequently, complete grounding systems include buried conductors, ground rods and connections, plus soil and vegetation in the area. Soil and vegetative conditions affect water retention and drainage, which impact overall performance of the grounding system. Typical THESL installations include 15 ground rods in a 100’ x 100’ lot at 13.8 kV stations.

31.1 Degradation Mechanism

Transmission station grounding systems keep ground potential rise, step and touch potentials below specified limits when maximum (i.e. worst case) ground faults occur. Under fault conditions, the following factors determine step and touch potentials:

- Magnitude of the fault current
- Resistance of ground combined with the ground grid consisting of station electrodes, transmission line sky wires and distribution neutrals
- Ground resistivity of upper and lower layers of earth.

Increases in system capacity and fault currents at a station may lead to unacceptable performance of the ground grid. Corrosion of buried conductors and connectors, mechanical damage to buried electrodes, plus burning-off of grounding conductors and connectors during heavy fault currents also may lead to unsatisfactory performance. Further, changes in resistivity of upper or lower layers of earth may adversely affect ground grid characteristics.

31.2 System Hierarchy

Grounding systems used in both the Transmission and Municipal Station systems.

31.3 Useful Life and Typical Life

Station grounding systems have a useful life range of 25 to 50 years; the typical life is 40 years [11][21][22].
32 Station Grounding Transformer

Electrical distribution systems can be configured as a grounded or ungrounded system. A grounded system has an electrical connection between source and the earth, whereas an ungrounded system has no intentional connection. Sometimes it is necessary to create a ground on an ungrounded system for safety or to aid in protective relaying applications. Grounding transformers, smaller transformers similar in construction to power transformers, are used in this application.

32.1 Degradation Mechanism
Like a majority of transformers, the end of life for this asset is a result of insulation degradation, more specifically, the failure of pressboard and paper insulation. Degradation of the insulating oil, and more significantly, paper insulation, typically results in end of life. Insulation degradation is a result of oxidation, a process that occurs in the presence of oxygen, high temperature, and moisture. For oil cooled transformers, particles, acids, and static electricity will also deteriorate the insulation.

32.2 System Hierarchy
Grounding transformers used in both the Transmission and Municipal Station systems.

32.3 Useful Life and Typical Life
Station grounding transformers have a typical life range of 30 to 40 years; the typical life of this asset is 40 years [23][24].

32.4 Time Based Maintenance Intervals
The typical routine inspection interval for this asset class is three years.
33 SCADA RTU

Supervisory Control and Data Acquisition (SCADA) refers to the centralized monitoring and control system of a facility. SCADA remote terminal units (RTUs) allow the master SCADA system to communicate, often wirelessly, with field equipment. In general, RTUs collect digital and analog data from equipment, exchange information to the master system, and perform control functions on field devices. They are typically comprised of the following: power supply, CPU, I/O Modules, housing and chassis, communications interface, and software.

33.1 Degradation Mechanism

There are many factors that contribute to the end-of-life of RTUs. Utilities may choose to upgrade or replace older units that are no longer supported by vendors or where spare parts are no longer available. Because RTUs are essentially computer devices, they are prone to obsolescence. For example, older units may lack the ability to interface with Intelligent Electronic Devices (IEDs), be unable to support newer or modern communications media and/or protocols, or not allow for the quantity, resolution, and accuracy of modern data acquisition. Legacy units may have limited ability of multiple master communication ports and protocols, or have an inability to segregate data into multiple RTU addresses based on priority.

33.2 System Hierarchy

SCADA RTUs are used in both the Transmission and Municipal Station systems.

33.3 Useful Life and Typical Life

The useful life range of SCADA RTU is 15 to 30 years; the typical life is 20 years [26][27].
34 Automatic Transfer Switch (ATS)

Automatic Transfer Switches (ATSs) are designed to operate in several different configurations and controls can be generally configured to suit different operating scenarios. Open transition transfer switches are the simplest kind. They are mechanically interlocked to ensure that the power from one source is disconnected before the connection is made to the other source. The closed transition transfer switches eliminate momentary power interruption when both sources are present and synchronized, by transferring the loads with an overlapping contact arrangement. The soft load closed transition switch extends the overlap time to multiple seconds, for a smoother transition of load to the standby source.

The transfer switches are generally electrically operated and mechanically held and have auxiliary contacts for control circuits. Main contacts are commonly made of silver alloy to resist welding and sticking during load transfers. They are mounted either in ventilated or submersible enclosures depending on the installation location. Just like circuit breakers, the heavy duty switches are often equipped with arc chutes to extinguish switching arcs.

34.1 Degradation Mechanism
The health degradations the transfer switch is subjected to include:

- contact wear
- wear and tear of the mechanical operating mechanism
- degradation of insulator supports and inter-phase barriers
- corrosion of the switch tank
- failure of the tanks seals allowing penetration of the moisture

Since the primary purpose of transfer switches is to ensure high reliability for critical loads, it is imperative that any interruptions due to the failure of the switch itself be avoided.

34.2 System Hierarchy
THESL uses Automatic Transfer Switches in the Underground system.

34.3 Useful Life and Typical Life
The useful life range of ATS is 30 to 50 years; the typical life is 45 years [2][23].

34.4 Time Based Maintenance Intervals
The typical routine inspection interval for this asset class is 3 years.
35 Network Transformer

Network transformers are special purpose distribution transformers, designed and constructed for successful operation in a parallel mode with a large number of transformers of similar characteristic. The spot network transformers can range in nameplate rating from 500 kVA to 1500 kVA. The primary winding of the transformers is connected in Delta configuration while the secondary is in grounded star configuration. The network transformers are provided with a primary disconnect, which has no current interrupting rating and is used merely as in isolating device after the transformer has been de-energized both from primary and secondary source. The secondary bushings are mounted on the side wall of the transformer in a throat, suitable for mounting of the network protector.

Network protectors are special purpose low voltage air circuit breakers, designed for successful parallel operation of network transformers. Network protectors are fully self contained units, equipped with protective relays and instrument transformers to allow automatic closing and opening of the protector. The relays conduct a line test before initiating close command and allow closing of the breaker only if the associated transformer has the correct voltage condition in relation to the grid to permit flow of power from the transformer to the grid. If the conditions are not right, protector closing is blocked. The protector is also equipped with a reverse current relay that trips if the power flow reverses from its normal direction, i.e. if the power flows from grid into the transformer.

35.1 Degradation Mechanism

Since in a majority of the applications transformers are installed in below grade vaults, the transformer is designed for partially submersible operation with additional protection against corrosion. While network transformers are available in dry-type (cast coil and epoxy impregnation) designs, a vast majority of the network transformers employ mineral oil for insulation and cooling. The network transformer has a similar degradation mechanism to other distribution transformers.

The life of the transformer’s internal insulation is related to temperature rise and duration. Therefore, the transformer life is affected by electrical loading profiles and length of service life. Other factors such as mechanical damage, exposure to corrosive salts, and voltage current surges also have strong effects. Therefore, a combination of condition, age, and load based criteria is commonly used to determine the useful remaining life.

The breaker design in network protectors employs mechanical linkages, rollers, springs and cams for operation which require periodic maintenance. All network protectors are equipped with special load-side fuses, mounted either internally or external to the network protector housing. The fuses are intended to allow normal load current and overloads while providing backup protection in the event that the protector fails to open on reverse fault current (due to faults internal to the protector or near transformer low voltage terminals). Every time arcing occurs in open air within the network protector housing, whether due to operation of the air breaker or because of fuse blowing (except silver sand), a certain amount of metal vapour is liberated and dispersed over insulating parts. Fuses evidently liberate more vapour than breaker operation. Over time, this
buildup reduces the dielectric strength of insulating barriers. Eventually this may result in a breakdown, unless care is taken to clean the network protector internally, particularly after fuse operations. THESL typically replaces protectors with new or refurbished protectors if the backup fuses have been found to have operated.

Various parameters that impact the health and condition and eventually lead to end of life of a network include condition of mechanical moving parts, condition of inter phase barriers, number of protector operations (counter reading), accumulation of dirt or debris in protector housing, corrosion of protector housing, condition of fuses, condition of arc chutes and time period elapsed since last major overhaul of the protector.

The health of network protector is established by taking into account the following factors:

- Number of operations since last overhaul
- Operating age of protector
- Condition of operating mechanism
- Condition of fuses
- Condition of arc chutes
- Condition of protector relays
- Condition of gaskets and seals for submersible units

35.2 System Hierarchy
THESL uses network transformers and protectors in the Underground system.

35.3 Useful Life and Typical Life
This asset class can be componentized into the following:

- Network Transformer
- Network Protector

35.3.1 Network Transformer
The useful life range of the transformer is 20 to 50 years; typical life is 35 years [2][23].

35.3.2 Network Protector
The useful life range of the protector is 20 to 40 years; typical life is 35 years [2][23].

35.4 Time Based Maintenance Intervals
The typical routine inspection schedule for both the transformer and protector components is every two years.
36 Pad Mounted Transformer

Pad mounted transformers are amongst the distribution transformers employed by THESL, with the transformer being single phase, 100 kVA, 16 kV. These transformers typically employ sealed tank construction and are liquid filled, with mineral insulating oil being the predominant liquid.

36.1 Degradation Mechanism

The pad-mounted transformer has a similar degradation mechanism to other distribution transformers. It has been demonstrated that the life of the transformer’s internal insulation is related to temperature rise and duration. Therefore, the transformer life is affected by electrical loading profiles and length of service life. Other factors such as mechanical damage, exposure to corrosive salts, and voltage current surges also have strong effects. Therefore, a combination of condition, age, and load based criteria is commonly used to determine the useful remaining life.

In general, the following are considered when determining the health of the pad-mounted transformer:

- Tank corrosion, condition of paint
- Extent of oil leaks
- Condition of bushings
- Condition of padlocks, warning signs, etc.
- Transfer operating age and winding temperature profile

36.2 System Hierarchy

Pad mounted transformers are used in the Underground system.

36.3 Useful Life and Typical Life

Pad mounted transformers have a useful life range of 30 to 40 years; the typical life is 40 years [23][24].
37 Vault Transformer

Vault transformers are amongst the distribution transformers employed by THESL, with the typical transformer being single phase, 100 kVA, 16 kV. These transformers typically employ sealed tank construction and are liquid filled, with mineral insulating oil being the predominant liquid.

37.1 Degradation Mechanism

The vault transformer has a similar degradation mechanism to other distribution transformers. The life of the transformer’s internal insulation is related to temperature rise and duration, so transformer life is affected by electrical loading profiles and length of service life. Mechanical damage, exposure to corrosive salts, and voltage current surges have strong effects. In general, a combination of condition, age, and load based criteria is commonly used to determine the useful remaining life.

37.2 System Hierarchy

Vault transformers are used in the Underground system.

37.3 Useful Life and Typical Life

Vault transformers have a useful life range of 30 to 40 years; the typical life is 40 years [23][24].

37.4 Time Based Maintenance Intervals

The typical routine inspection schedule for this asset is every two years.
38 Submersible Transformer

Submersible transformers are amongst the distribution transformers employed by THESL, with the typical transformer being single phase, 100 kVA, 16 kV. These transformers typically employ sealed tank construction and are liquid filled, with mineral insulating oil being the predominant liquid.

38.1 Degradation Mechanism
The submersible transformer has a similar degradation mechanism to other distribution transformers. The life of the transformer’s internal insulation is related to temperature rise and duration, so transformer life is affected by electrical loading profiles and length of service life. Mechanical damage, exposure to corrosive salts, and voltage current surges have strong effects. In general, a combination of condition, age, and load based criteria is commonly used to determine the useful remaining life.

38.2 System Hierarchy
Submersible transformers are used in the Underground system.

38.3 Useful Life and Typical Life
Submersible transformers have a useful life range of 25 to 40 years; the typical life is 35 years [23][24].

38.4 Time Based Maintenance Intervals
The typical routine inspection schedule for this asset is every two years.
39 Network Vault

Equipment vaults permit installation of transformers, switchgear or other equipment. Utility vaults are often constructed out of reinforced or un-reinforced concrete. Vaults used for transformer installation are often equipped with ventilation grates to provide natural or forced cooling. The typical network vault size used by THESL is 2.3m W x 6.4m L x 3.4m H.

39.1 Degradation Mechanism
Vaults should be capable of bearing the loads that are applied on them. As such, mechanical strength is a basic end of life parameter for a vault. Although age is loosely related to the condition of underground civil structures, it is not a linear relationship. Other factors such as mechanical loading, exposure to corrosive salts, etc. have a stronger effect. Degradation commonly includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers or rings. Acidic salts (i.e. sulfates or chlorides) affect corrosion rates. In roadways, defects exist when covers are not level with street surfaces. Conditions that lead to flooding, clogged sumps, and non-functioning sump-pumps also represent major deficiencies. Similarly, units with lights that do not function properly constitute defective systems.

39.2 System Hierarchy
Network vaults are used in the Underground system.

39.3 Useful Life and Typical Life
The overall useful life range of network vaults is 40 to 80 years; the typical life is 60 years [1][23][27].

A major component of this asset is the roof, as this component is typically rebuilt one to two times during the life of the vault.

39.3.1 Roof
The roof has a useful life range of 20 to 30 years, with a typical life of 25 years.

39.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
40 Radial Vault

As with other types of underground vaults, radial vaults allow for the underground installation of equipment. The typical radial vault size used by THESL is 3.0m W x 8.5m L x 3.66m H.

40.1 Degradation Mechanism
For radial vaults, as with network vaults and other underground civil structures, mechanical strength is an end of life parameter. Age, mechanical loading, and exposure to corrosive are factors. Degradation includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers. Exposure to acidic salts affects corrosion rates. Improperly functioning sump pumps or lights also constitute defective systems.

40.2 System Hierarchy
Radial vaults are used in the Underground system.

40.3 Useful Life and Typical Life
The useful life range of radial vaults is 40 to 80 years; the typical life is 60 years [1][23][27].

A major component of this asset is the roof, as this component is typically rebuilt one to two times during the life of the vault.

40.3.1 Roof
The roof has a useful life range of 20 to 30 years, with a typical life of 25 years.

40.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
41 Underground Residential Distribution (URD) Vault

As with other types of underground vaults, URD vaults allow for the underground installation of equipment. The typical URD vault size used by THESL is 1.5m W x 3.5m L x 2.1m H.

41.1 Degradation Mechanism
For URD vaults, as with other underground civil structures, mechanical strength is an end of life parameter. Age, mechanical loading, and exposure to corrosive are factors. Degradation includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers. Exposure to acidic salts affects corrosion rates. Improperly functioning sump pumps or lights also constitute defective systems.

41.2 System Hierarchy
URD vaults are used in the Underground system.

41.3 Useful Life and Typical Life
The useful life range of this asset class is 40 to 80 years; the average life is 60 years [1][23][27].

A major component of this asset is the roof, as this component is typically rebuilt one to two times during the life of the vault.

41.3.1 Roof
The roof has a useful life range of 20 to 30 years, with a typical life of 25 years.

41.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
42 Submersible Vault

As with other types of underground vaults, submersible vaults allow for the underground installation of equipment. The typical submersible vault size used by THESL is 1.24m W x 2.26m L x 1.98m H.

42.1 Degradation Mechanism
For submersible vaults, as with other underground civil structures, mechanical strength is an end of life parameter. Age, mechanical loading, and exposure to corrosive are factors. Degradation includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers. Exposure to acidic salts affects corrosion rates. Improperly functioning sump pumps or lights also constitute defective systems.

42.2 System Hierarchy
Submersible vaults are used in the Underground system.

42.3 Useful Life and Typical Life
The useful life range of this asset class is 40 to 80 years; the average life is 60 years [1][23][27].

A major component of this asset is the roof, as this component is typically rebuilt one to two times during the life of the vault.

42.3.1 Roof
The roof has a useful life range of 20 to 30 years, with a typical life of 25 years.

42.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
43 Cable Chamber

Cable Chambers facilitate cable pulling into underground ducts and provide access to splices and facilities that require periodic inspections or maintenance. They come in different styles, shapes and sizes according to the location and application. Pre-cast cable chambers are normally installed only outside the traveled portion of the road although some end up under the road surface after road widening. Cast-in-place cable chambers are used under the traveled portion of the road because of their strength and also because they are less expensive to rebuild if they should fail. Customer cable chambers are on customer property and are usually in a more benign environment. Although they supply a specific customer, system cables loop through these chambers so other customers could also be affected by any problems.

43.1 Degradation Mechanism

These assets must withstand the heaviest structural loadings that they might be subjected to. For example, when located in streets, utility chambers must withstand heavy loads associated with traffic in the street. When located in driving lanes, cable chamber chimney and collar rings must match street grading. Since utility chambers and vaults often experience flooding, they sometimes include drainage sumps and sump pumps. Nevertheless, environmental regulations in some jurisdictions may prohibit the pumping of utility chambers into sewer systems, without testing of the water for environmentally hazardous contaminants.

Although age is loosely related to the condition of underground civil structures, it is not a linear relationship. Other factors such as mechanical loading, exposure to corrosive salts, etc. have stronger effects. Cable chamber degradation commonly includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers or rings. Acidic salts (i.e. sulfates or chlorides) affect corrosion rates. Cable chamber systems also may experience a number of deficiencies or defects. In roadways, defects exist when covers are not level with street surfaces. Conditions that lead to flooding, clogged sumps, and non-functioning sump-pumps also represent major deficiencies in a cable chamber system. Similarly, cable chamber systems with lights that do not function properly constitute defective systems. Deteriorating ductwork associated with cable chambers also requires evaluation in assessing the overall condition of a cable chamber system.

43.2 System Hierarchy

Cable chambers are used in the Underground system.

43.3 Useful Life and Typical Life

Cable chambers have a useful life range of 50 to 80 years; the typical life range is 60 years [2][23][28].

A major component of this asset is the roof, as this component is typically rebuilt one to two times during the life of the vault.
43.3.1 Roof
The roof has a useful life range of 20 to 30 years, with a typical life of 25 years.

43.4 Time Based Maintenance Intervals
The typical routine testing/maintenance interval for this asset class is three years.
44 Duct Bank

In areas such as road crossings, duct banks provide a conduit for underground cables to travel. They are comprised of a number of ducts, in trench, and typically encased in concrete. Ducts are sized as required and are usually four, five or six inches in diameter. The typical duct bank installation by THESL is 3 W x 2 H.

44.1 Degradation Mechanism
The ducts connecting one cable chamber to another cannot easily be assessed for condition without excavating areas suspected of suffering failures. However, water ingress to a cable chamber that is otherwise in sound condition is a good indicator of a failure of a portion of the ductwork. Since there are no specific tests that can be conducted to determine duct integrity at reasonable cost, the duct system is typically treated on an ad hoc basis and repaired or replaced as is determined at the time of cable replacement or failure.

44.2 System Hierarchy
Duct banks are used in the Underground system.

44.3 Useful Life and Typical Life
Duct banks have a typical useful life of 30 to 80 years; the average life is 50 years [2][23].
45 Padmounted Switchgear (SF6/Vacuum)

Pad-mounted switchgear are used for protection and switching in the underground distribution system. The switching assemblies can be classified into SF6 load break switches and vacuum fault interrupters.

45.1 Degradation Mechanism
The pad-mounted switchgear is very infrequently used for switching and often used to drop loads way below its rating. Therefore, switchgear aging and eventual end of life is often established by mechanical failures, e.g. rusting of the enclosures or ingress of moisture and dirt into the switchgear causing corrosion of operating mechanism and degradation of insulated barriers.

The first generation of pad mounted switchgear was first introduced in early 1970’s and many of these units are still in good operating condition. The life expectancy of pad-mounted switchgear is impacted by a number of factors that include frequency of switching operations, load dropped, presence or absence of corrosive environmental and absence of existence of dampness at the installation site.

In the absence of specifically identified problems, the common industry practice for distribution switchgear is running it to end of life, just short of failure. To extend the life of these assets and to minimize in-service failures, a number of intervention strategies are employed on a regular basis: e.g. inspection with thermographic analysis and cleaning with CO2 for air insulated pad-mounted switchgear. If problems or defects are identified during inspection, often the affected component can be replaced or repaired without a total replacement of the switchgear.

Failures of switchgear are most often not directly related to the age of the equipment, but are associated instead with outside influences. For example, pad-mounted switchgear is most likely to fail due to rodents, dirt/contamination, vehicle accidents, rusting of the case, and broken insulators caused by misalignment during switching. All of these causes are largely preventable with good design and maintenance practices. Failures caused by fuse malfunctions can result in a catastrophic switchgear failure.

45.2 System Hierarchy
Pad-mounted switchgear are used in the Underground system.

45.3 Useful Life and Typical Life
The useful life range of this asset class is 30 to 50 years; the typical life is 30 years [31].

45.4 Time Based Maintenance Intervals
The typical routine inspection interval for this asset is three years.
46 Padmounted Switchgear (Air Insulated)

Pad-mounted switchgear are used for protection and switching in the underground distribution system. The switching assemblies can be air insulated. A majority of the pad mounted switchgear currently employs air-insulated gang operated load-break switches.

46.1 Degradation Mechanism
The degradation of the air insulated padmounted switchgear is similar to that of the SF6 switchgear. Aging and end of life is established by mechanical failures, such as corrosion of operating mechanism from rusting of enclosure or moisture and dirt ingress. Switchgear failure is associated more with outside influences rather than age. For example, switchgear failure is more likely to be caused by rodents, dirt or contamination, vehicle accidents, rusting of the case, and broken insulators caused by misalignment during switching.

46.2 System Hierarchy
Pad-mounted switchgear are used in the Underground system.

46.3 Useful Life and Typical Life
The useful life range of this asset class is 20 to 40 years; typical life is 20 years [30][29].

46.4 Time Based Maintenance Intervals
The typical routine inspection interval for this asset is 3 years.
47 SF6/Vacuum Underground Switches

The underground SF6/Vacuum switches used by THESL are Loadbreak, Vacuum, 3PH, 15KV, 200AMP, 2-WAY 1-SWITCHED (Kearney Part Number 21VP95-22) or 3-WAY 3-SWITCHED (Kearney Part Number 33VP95-222). These units are essentially pad mounted switchgear, enclosed in stainless steel containers, with the ability to be wall or ceiling mounted.

47.1 Degradation Mechanism
The degradation mechanism of this asset is similar to that of other types of padmounted switchgear. Aging and end of life is established by mechanical failures, such as corrosion of operating mechanism from rusting of enclosure or moisture and dirt ingress. Switchgear failure is associated more with outside influences rather than age. For example, switchgear failure is more likely to be caused by rodents, dirt or contamination, vehicle accidents, rusting of the case, and broken insulators caused by misalignment during switching.

47.2 System Hierarchy
SF6/Vacuum Underground switches are used in the Underground system.

47.3 Useful Life and Typical Life
The useful life range of this asset class is 30 to 50 years; the typical life is 30 years [31].

47.4 Time Based Maintenance Intervals
The typical routine inspection interval for this asset is 3 years.
48 Underground Primary Cable (XLPE in Duct)

Distribution underground cables are mainly used in urban areas where it is either impossible or extremely difficult to build overhead lines due to aesthetic, legal, environmental and safety reasons. The initial capital cost of a distribution underground cable circuit is three or more times the cost of an overhead line of equivalent capacity and voltage. The cross linked polyethylene (XLPE) cable in duct is amongst the types of underground distribution cables used by THESL.

48.1 Degradation Mechanism

Over the past 30 years XLPE insulated cables have all but replaced paper-insulated cables. These cables can be manufactured by a simple extrusion of the insulation over the conductor and therefore are much more economic to produce. In normal cable lifetime terms XLPE cables are still relatively young. Therefore, failures that have occurred can be classified as early life failures. Certainly in the early days of polymeric insulated cables their reliability was questionable. Many of the problems were associated with joints and accessories or defects introduced in the manufacturing process. Over the past 30 years many of these problems have been addressed and modern XLPE cables and accessories are generally very reliable.

Polymeric insulation is very sensitive to discharge activity. It is therefore very important that the cable, joints and accessories are discharge free when installed. Discharge testing is, therefore, an important factor for these cables. This type of testing is conducted during commissioning and is not typically used for detection of deterioration of the insulation. These commissioning tests are an area of some concern for polymeric cables because the tests themselves are suspected of causing permanent damage and reducing the life of polymeric cables.

Water treeing is the most significant degradation process for polymeric cables. The original design of cables with polymeric sheaths allowed water to penetrate and come into contact with the insulation. In the presence of electric fields water migration can result in treeing and ultimately breakdown. The rate of growth of water trees is dependent on the quality of the polymeric insulation and the manufacturing process. Any contamination, voids or discontinuities will accelerate degradation. This is assumed to be the reason for poor reliability and relatively short lifetimes of early polymeric cables. As manufacturing processes have improved the performance and ultimate life of this type of cable has also improved.

48.2 System Hierarchy

Underground cables are used in the Underground system.

48.3 Useful Life and Typical Life

The useful life range of this asset class is 40 to 60 years; typical life is 40 years [9][2].
49 Underground Primary Cable (XLPE Direct Buried)

While cross linked polyethylene (XLPE) underground cable can be installed in ducts, it can also be directly buried.

49.1 Degradation Mechanism
The degradation of the directly buried cable is similar to that of the XLPE cable in duct. Polymeric insulation is sensitive to discharge activities. Water treeing is a significant deterioration process, and the degree is a factor of contamination and quality of polymeric insulation.

49.2 System Hierarchy
Underground cables are used in the Underground system.

49.3 Useful Life and Typical Life
The useful life range of this asset class is 20 to 25 years; typical life is 25 years [32][2].
50 Underground Primary Cable (PILC)

The Paper Insulated Lead Covered (PILC) cable is amongst the types of underground distribution cables used by THESL.

50.1 Degradation Mechanism

For PILC cables, the two significant long-term degradation processes are corrosion of the lead sheath and dielectric degradation of the oil impregnated paper insulation. Isolated sites of corrosion resulting in moisture penetration or isolated sites of dielectric deterioration resulting in insulation breakdown can result in localized failures. However, if either of these conditions becomes widespread there will be frequent cable failures and the cable can be deemed to be at effective end-of-life.

As discussed above, condition information relating to either of these degradation processes is very difficult to obtain. Generally, the only opportunity to obtain useful condition information is at the time of a failure and repair. Examination and analysis of faulted sections can therefore be an important condition assessment process. Firstly, it is essential to discriminate between condition related and non-condition related cable failures. Third party damage is a major cause of failure, either immediately following damage or a failure that occurs subsequently as the result of earlier damage. Clearly, if frequency of failures is to be used as a measure to determine end-of-life it is important that only condition based failures are included. Systematic analysis and assessment of condition of cables associated with failure positions can, over a period of time, build up, a useful picture of the condition of the cable network.

50.2 System Hierarchy

Underground cables are used in the Underground system.

50.3 Useful Life and Typical Life

The useful life range of this asset class is 70 to 80 years; the typical life is 75 years [32][33].
51 Underground Secondary (In Duct)

Secondary underground cables are used as feeders to residential premises. The typical cable used by THESL is Cable 500 kcmil Cu XLPE 600V.

51.1 Degradation Mechanism
Underground secondary conductors are typically insulated with XLPE. The degradation process is similar to that of primary XLPE cables. Polymeric insulation is sensitive to discharge activities. Water treeing is a significant deterioration process, and the degree is a factor of contamination and quality of polymeric insulation.

51.2 System Hierarchy
Underground cables are used in the Underground system.

51.3 Useful Life and Typical Life
The useful life range of this asset class is 40 to 60 years; the typical life is 40 years [9][2].
52 Underground Secondary (DB)

While secondary underground cables can be buried in duct, they can also be direct buried. The typical secondary cable used by THESL is Cable 500 kcmil Cu XLPE 600V.

52.1 Degradation Mechanism
Underground secondary conductors are typically insulated with XLPE. The degradation process is similar to that of primary XLPE cables. Polymeric insulation is sensitive to discharge activities. Water treeing is a significant deterioration process, and the degree is a factor of contamination and quality of polymeric insulation.

52.2 System Hierarchy
Underground cables are used in the Underground system.

52.3 Useful Life and Typical Life
The useful life range of this asset class is 20 to 25 years; the typical life is 25 years [32][2].
53 Lighting Assemblies (Conventional)

Conventional streetlights powered by underground cabling are used to illuminate streets and roadways. The major components of conventional street lighting are poles, luminaires, cabling, and civil components (i.e. duct, handwell).

53.1 Degradation Mechanism
The poles used for street lighting are commonly made of steel, aluminum, or concrete. The typical pole materials used by THESL are aluminum and concrete. Environmental stresses contribute to the corrosion of aluminum poles. Luminaires used in street lighting may be prone to corrosion. In addition, continuous exposure of polycarbonate optics to ultraviolet light can result in diminished light level output.

53.2 System Hierarchy
Streetlights fed by underground cables are used in the Underground system.

53.3 Useful Life and Typical Life
Conventional lighting assemblies can be componentized into the following:
- Cabling
- Civil (duct, handwell)
- Pole (aluminum)
- Luminaire

53.3.1 Cabling
The useful life range of streetlight cabling is 40-60 years; typical life is 40 years [32][2].

53.3.2 Civil (Handwell, Tap Box)
The useful life range of the civil components is 50-60 years; typical life is 50 years [23].

53.3.3 Poles
The useful life range of the poles is 40-60 years; the typical life is 50 years [35].

53.3.4 Luminaire
The useful life range of the luminaire is 20-30 years; the typical life is 25 years [10].

53.4 Time Based Maintenance Intervals
The routine inspection interval for this asset is four years.
54 References


[3] H.E. Painter et al., *Modular Terminations for Electrical and Optical Cables with Increased Reliability and Simplified Installation*, Brazilian Petroleum, Gas and Biofuels Institute


[18] Custom Power Company, *BCF1 and BCF3 – Filtered Battery Chargers*


[31] H Le Bars, *SF6 Switchgear Complies with Sustainable Environment*, Schneider Electric, 2004


[33] G.D. Hendley, *Cold Shrink Termination Speeds Cable Installation*, Texas Utilities Electric


RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 39:
Reference(s): Exhibit 2B, Section D2

Please provide a table showing for each major asset type, the number of assets currently in each of the ACA Health Index categories (HI 1 to 5).

RESPONSE:
Please refer to Exhibit 2B, Section D, Appendix C, Table 2 for a table showing major asset types and the number of assets currently in each of the ACA Health Index categories (HI1 to HI5).
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 40:

Reference(s): Exhibit 2B, Section D2

Please provide a table showing for each major asset type, the number of assets replaced in each year between 2015 and 2018, and forecast to replace in each year between 2019 and 2024.

RESPONSE:

Please refer to the Toronto Hydro’s response to 2B-SEC-51. For all assets replaced reactively, please refer to Toronto Hydro’s response to 2B-AMPCO-62.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 41:

Reference(s): Exhibit 2B, Section D3, p.30-31

Please explain how and where the Feeder Investment Model is used in the planning process. Please use examples to illustrate.

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-67(e) for details on how the Feeder Investment Model, referred to as economic risk-based analysis within that response, is used in the planning process.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 42:
Reference(s): Exhibit 2B, Section D4

With respect to the Facilities Management Asset Management renewal process:

a) Please explain what is meant by a Lifecycle analysis. Please provide a copy of such an analysis as an example.

b) Please explain the CMMS analysis and provide details.

RESPONSE:

a) A Lifecycle Analysis, as referenced in Exhibit 2B, Section D4, is the condition assessment of a particular asset. Please see Appendix A, for a sample Lifecycle Analysis completed on a Toronto Hydro substation.

b) The Computerized Maintenance Management System ("CMMS") is a database that contains information about Toronto Hydro’s facilities related assets, work programs, and history. It enables Toronto Hydro to:

- Schedule and document preventive maintenance tasks;
- Track equipment history;
- Maintain labor records;
- Allocate resources;
- Generate work orders; and
- Manage equipment costs.
The CMMS analysis is undertaken by reviewing the types of data listed above. This resulting data provides information pertaining to reactive maintenance, tenant requests, equipment downtime, overdue preventive maintenance tasks, maintenance costs, and labor utilization.
Facilities Management & Operations

Report By:

Toronto Hydro Corporation

Building Condition Assessment and Lifecycle Analysis

- 233 Adelaide St E - George & Duke Station

Version 2017

January 2018
1.0 Executive Summary

This report is the culmination of planning and work completed by Toronto Hydro Facilities department, our partner consultants and subcontractors.

- **Report Structure**

  This report includes observations, major findings, recommendations, and supporting pictures. For ease and budgetary purposes the major findings and recommendations are broken out by Uniformat II classification of building systems or Toronto Hydro asset numbers (i.e. TH00001234) where appropriate.

  - Cost data for all recommendations are for budgetary purposes and are subject to the limits, as described below, of this report.
  - Top level (Level 1) categories for Uniformat II are:
    - Substructure
    - Shell
    - Interiors
    - Services
    - Equipment & Furnishings
    - Special Construction & Demolition
    - Building Site Work
  - All observations and findings are identified through visual inspection. Any further investigation would be out of scope of this report. Where available, independent vendors and past assessments have been engaged and sited to support the recommendations.
  - The focus on this report is to identify assets and building systems that require major capital repair or replacement within 1-5 years. A further recommendation of assets needing major repair or replacement is also given for 5-10 years.
  - This report will be reference and updated annually using similar means with a mind for continual improvements specific to the Toronto Hydro service agreement.

2.0 Scope and Methodology

The scope of this report includes a visual examination of the following:
- Exposed Foundation
- Main Wall Construction
- Retaining Walls
- Structural Steel
- Painting Provisions
- Man Door Entrances
- Equipment Entrances
- Windows
- Soffit
- Facia
- Drainage System
- Main Roof System
- Driveway
- Walkway
- Fencing
- Gates
- Exterior Lighting
- Landscape
- Community Impact
The reported is a culmination of all available documents, including but not limited to:

- Pinchin’s 2011 BCA submitted to THES and provided to B&M
- Life Cycle Cost Analysis & Equipment Assessment from 2013
- Refurbishment and Renewal Project from 2011 including:
  - Assessments from MMM group
  - Quotations for Painting
  - Roof Assessments
- Garland Roof Assessment Reports from 2014
- Toronto Hydro data base of equipment assets
- Toronto Hydro work order backlog from 2014- December 2017.
- Toronto Hydro provided drawings, profiles, and runoffs
- Scope Matrix from the Service Agreement
- ITC’s Risk Assessment from 2015
- Toronto Hydro Occupied and Substation Quote Log
- Engagement with currently Toronto Hydro approved vendors
- Deficiency reports and certificates collected by Facilities Supervisors from 2014-2017

Cost estimates provided in this report are considered preliminary and backed by a small sample of previous complete work, previously reported costs of similar work, and a brief engagement with 8 contractors (see appendix A for details on vendor quotes).

All prices are updated and provided in 2017 Canadian Dollars and exclude any engineering/consulting fees or taxes. More precise cost estimates and scope of work would be needed before any work starts. Cost estimation databases such as RS Means Maintenance and Repair Cost Data were used. Consideration for safety and security around high voltage equipment has been observed with an addition of PIA, alarm bypass, and general cost escalation. The specifics of the budget cost are indicated by the noted recommendations; exact measurements are out of scope of this report and so estimation based on available drawings, condition assessment, past reports, and pictures were used to generate the budget cost.

As per Facilities Asset Management Strategy, Condition and Priority Rating was given to each identified building system with the following standardized rubric:

### Table 3

<table>
<thead>
<tr>
<th>Rating</th>
<th>Condition</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3</td>
<td>Poor</td>
<td>Budget within 1-5 years</td>
</tr>
<tr>
<td>4, 5, 6</td>
<td>Fair</td>
<td>Budget within 5-10 years</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>Good</td>
<td>Placeholder; no recommendation</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Rating</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Critical System</td>
</tr>
<tr>
<td>2</td>
<td>Building Functionality</td>
</tr>
<tr>
<td>3</td>
<td>Run to fail/low impact</td>
</tr>
<tr>
<td>4</td>
<td>Redundancy or Cost Effective Upgrade</td>
</tr>
</tbody>
</table>
3.0 Site Description and Overview

The property is located at 233 Adelaide St E and has a total area of 18090 sq. ft. The site building was built in 1929 and is used as an active substation, contains switch gear and services the Toronto area.
3.1 Cost Summary

Graphs 1

**Budget Summary**

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 Years</td>
<td>$912,280</td>
</tr>
<tr>
<td>6-10 Years</td>
<td>$149,890</td>
</tr>
</tbody>
</table>

**No of Assets that need repairs/replacement**

- 1-5 Years: 18
- 6-10 Years: 8
4.0 Lifecycle Plan Details

4.1 Lifecycle Plan 1-5 Years
See appendix A

4.2 Lifecycle Plan for 6-10 Years
See appendix A

4.3 Lifecycle Plan for Past 10 Year Focus
See appendix A

5.0 Current and Historic Photos

<table>
<thead>
<tr>
<th>Exterior Doors</th>
<th>South elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 metal door and metal frame. 2x Painted hollow metal door and metal frame. 1 wood door with wood frame.</td>
<td></td>
</tr>
</tbody>
</table>

2016
Building Condition Assessment and Lifecycle Analysis: George & Duke Station

<table>
<thead>
<tr>
<th>Interior Door Missing</th>
<th>Basement</th>
<th>Wood frame</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interior Wall finishes</th>
<th>1st floor south west room</th>
<th>Painted concrete and metal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floor finishes.</th>
<th>Basement</th>
<th>Clay tiles and painted concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floor finishes.</th>
<th>1st Level South room.</th>
<th>Painted concrete Handrails</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Building Condition Assessment and Lifecycle Analysis: George & Duke Station

### Ceiling Finishes

<table>
<thead>
<tr>
<th>Basement</th>
<th>Painted concrete</th>
</tr>
</thead>
</table>

### Driveway

<table>
<thead>
<tr>
<th>South of the site building</th>
<th>Asphalt</th>
</tr>
</thead>
</table>

![Image of ceiling finishes]

![Image of driveway]

![Image of paint and concrete]

---

*Note: The images are of the building exterior and interior, showing various conditions and materials used in the construction.*
Facilities Management & Operations

Building Condition Assessment and Lifecycle Analysis: George & Duke Station

<table>
<thead>
<tr>
<th>Exterior Door</th>
<th>South Elevation</th>
<th>Metal door and metal frame</th>
</tr>
</thead>
</table>

Floor Finishes

<table>
<thead>
<tr>
<th>Basement</th>
<th>Painted Concrete and Brick</th>
</tr>
</thead>
</table>

2017

Floor Finishes

<table>
<thead>
<tr>
<th>Basement</th>
<th>Painted Concrete</th>
</tr>
</thead>
</table>

2017

Floor Finishes

<table>
<thead>
<tr>
<th>Basement</th>
<th>Painted Concrete</th>
</tr>
</thead>
</table>
Building Condition Assessment and Lifecycle Analysis: George & Duke Station

Facilities Management & Operations

2017

Ceiling Finishes

Basement

Painted Concrete
<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stairs</td>
<td>1st level south</td>
<td></td>
</tr>
<tr>
<td>Interior Wall finishes</td>
<td>1st floor south</td>
<td>Painted concrete and metal</td>
</tr>
<tr>
<td>Floor Finishes</td>
<td>1st level south-east room</td>
<td>Clay tiles and painted concrete</td>
</tr>
</tbody>
</table>
## Budget 1-5 Years Detail

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item Name</th>
<th>Location</th>
<th>Serviced</th>
<th>Component</th>
<th>Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual / Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2144</td>
<td>C031001</td>
<td>Exterior Doors</td>
<td>South elevation</td>
<td>1 metal door and metal frame. 3x Painted hollow metal door and metal frame. 1 wood door with wood frame.</td>
<td>Poor. Corrosion on bottom of the door equipment entrance door. Multiple CMMS work orders for doors failing to close leading to after hours response/service calls.</td>
<td>2</td>
<td>Replace 1 door and frame within 5 years.</td>
<td>3</td>
<td>10</td>
<td>1980</td>
<td>R2 2</td>
<td>$5300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2147</td>
<td>C102001</td>
<td>Interior Door</td>
<td>Basement</td>
<td>4 metal door and frame. 1 Wood frame</td>
<td>Poor. Wood frame does have door removed. North east stairwell door does not close. These doors function as fire doors and hence need to be functional.</td>
<td>2</td>
<td>Replace 2 doors in the near future and repaint the remaining 3</td>
<td>2</td>
<td>35</td>
<td>1980</td>
<td>H2 2</td>
<td>$7000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2150</td>
<td>C031001</td>
<td>Wall Finishes</td>
<td>Basement</td>
<td>Painted Concrete and Brick</td>
<td>Poor. Wood frame does have door removed. North east stairwell door does not close. These doors function as fire doors and hence need to be functional.</td>
<td>2</td>
<td>Clean and paint walls in the near future.</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>H2 2</td>
<td>$41400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2151</td>
<td>C031001</td>
<td>Interior Wall finishes</td>
<td>1st Level south east room</td>
<td>Painted concrete.</td>
<td>Poor. Chipping paint and major cracking on west wall. North wall has large cracks which were previously sealed under window. Paint needed to preserve wall integrity.</td>
<td>2</td>
<td>Remove flaking paint and repaint white peel.</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>H2 2</td>
<td>$8950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2152</td>
<td>C031001</td>
<td>Interior Wall finishes</td>
<td>1st floor south west room</td>
<td>Painted concrete and metal</td>
<td>Poor. Paint peeling. Discoloration. North east corner has large cracks which were previously sealed under window. Paint needed to preserve wall integrity.</td>
<td>3</td>
<td>Repair and paint in the near future.</td>
<td>3</td>
<td>10</td>
<td>1990</td>
<td>H2 2</td>
<td>$8950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2154</td>
<td>C032005</td>
<td>Floor Finishes</td>
<td>Basement</td>
<td>Clay Tires and painted concrete</td>
<td>Poor. Floor tiles are chipping in front of switchgear. Floor penetrations not sealed. Painting, Uneven floor finish leading to trip hazards and distribution assets getting damaged while moving them during construction.</td>
<td>2</td>
<td>Repair in the near future. Fill all unused holes</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>R2 2</td>
<td>$39700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2155</td>
<td>C032005</td>
<td>Floor finishes</td>
<td>1st Level south east room</td>
<td>Tiles and concrete.</td>
<td>Poor. Concrete where the switch gear was is chipped and corroded. Unstable. Floor is dirty. Uneven floor finish leading to trip hazards and distribution assets getting damaged while moving them.</td>
<td>1</td>
<td>Clean floor and repair/paint concrete section.</td>
<td>1</td>
<td>10</td>
<td>1990</td>
<td>R2 2</td>
<td>$11600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Building Condition Assessment and Lifecycle Analysis: George & Duke Station

### Budget 6-10 Years Detail

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D034007</td>
<td>Exhaust Fan</td>
<td>Shower room Level 1</td>
<td>Fractional HP motor and fan</td>
<td>THD0001357</td>
<td>Poor. Does not work leading to high moisture and water damage in the area.</td>
<td>Replace immediately</td>
<td>2</td>
<td>20</td>
<td>1980</td>
<td>R2</td>
<td>2</td>
<td>$1200</td>
</tr>
<tr>
<td>D034008</td>
<td>AHU #3</td>
<td>Basement Main Room NE</td>
<td>15 Ton</td>
<td>THD0001372</td>
<td>Poor. Reported as needing replacement. CMMS work orders for corrective repairs: Heating and cooling issues.</td>
<td>Replace within the next 5 years.</td>
<td>2</td>
<td>25</td>
<td>2005</td>
<td>R2</td>
<td>2</td>
<td>$5000</td>
</tr>
<tr>
<td>D034008</td>
<td>AHU #2</td>
<td>Basement NW Room</td>
<td>15 Ton</td>
<td>THD0001382</td>
<td>Poor. Reported as needing replacement. CMMS work orders for corrective repairs: Heating and cooling issues.</td>
<td>Replace within the next 5 years.</td>
<td>2</td>
<td>25</td>
<td>2005</td>
<td>R2</td>
<td>2</td>
<td>$5000</td>
</tr>
</tbody>
</table>

---

### 2156

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C303003</td>
<td>Ceiling finishes</td>
<td>Basement</td>
<td>Painted concrete</td>
<td></td>
<td>Poor. Penetrations present. Paint peeling in various areas. ACMEDSS reports have confirmed lead containing paint presence in the substation.</td>
<td>Replace in the near future.</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>R2</td>
<td>2</td>
<td>$17400</td>
</tr>
</tbody>
</table>

---

### 2159

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C303003</td>
<td>Ceiling finishes</td>
<td>1st floor south west room</td>
<td>Painted concrete and 1 metal hatch</td>
<td></td>
<td>Poor. Old duct banks in disrepair and peeling paint. ACMEDSS reports have confirmed lead containing paint presence in the substation.</td>
<td>Replace in the near future.</td>
<td>3</td>
<td>10</td>
<td>1990</td>
<td>R2</td>
<td>2</td>
<td>$17400</td>
</tr>
</tbody>
</table>

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### 2160

<table>
<thead>
<tr>
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<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C303004</td>
<td>Ceiling finishes</td>
<td>1st Level south east room</td>
<td>Painted concrete</td>
<td></td>
<td>Poor. Paint peeling. ACMEDSS reports have confirmed lead containing paint presence in the substation.</td>
<td>Replace in the near future.</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>R2</td>
<td>2</td>
<td>$17400</td>
</tr>
</tbody>
</table>

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### 2161

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C303004</td>
<td>Ceiling finishes</td>
<td>1st Level North East room</td>
<td>Painted concrete</td>
<td></td>
<td>Poor. Unhurva paint peeling. ACMEDSS reports have confirmed lead containing paint presence in the substation.</td>
<td>Replace in the near future.</td>
<td>2</td>
<td>10</td>
<td>1990</td>
<td>R2</td>
<td>2</td>
<td>$17400</td>
</tr>
</tbody>
</table>

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### 2162

<table>
<thead>
<tr>
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<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C303004</td>
<td>Ceiling finishes</td>
<td>1st Level South west room</td>
<td>Painted concrete</td>
<td></td>
<td>Poor. Peeling paint. ACMEDSS reports have confirmed lead containing paint presence in the substation.</td>
<td>Replace in the near future.</td>
<td>3</td>
<td>10</td>
<td>1990</td>
<td>R2</td>
<td>2</td>
<td>$17400</td>
</tr>
</tbody>
</table>

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### 2176

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<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D023001</td>
<td>Fire alarm panel</td>
<td>Within the Site Building.</td>
<td>Cerberus Pyrotronics-System 3</td>
<td></td>
<td>Poor. Update panel. Parts not available. Failure may lead to high operational costs due to the watch and non-available spare parts.</td>
<td>Replace in the near future.</td>
<td>1</td>
<td>15</td>
<td>1993</td>
<td>R2</td>
<td>1</td>
<td>$510000</td>
</tr>
</tbody>
</table>

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### 2182

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D023001</td>
<td>Underground</td>
<td>South of the site building</td>
<td>Asphalt</td>
<td></td>
<td>Poor. Tilt, holes, and cracks. Observed some smimholes. Temporary repairs done in 2015. Sunken driveway leading to icy conditions.</td>
<td>Replace driveway in the near future.</td>
<td>3</td>
<td>20</td>
<td>1995</td>
<td>R2</td>
<td>2</td>
<td>$38000</td>
</tr>
</tbody>
</table>

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### 2142

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>B201001</td>
<td>Exterior Wall</td>
<td>Exterior of site building</td>
<td>Concrete foundation and brick</td>
<td></td>
<td>Fair. South west corner has cracked concrete slabs. Missing chunks of concrete. Minor buck point noted on south wall. Spalling brick might lead to safety incidents for employees/contractors and their vehicles.</td>
<td>Repair all deficiencies.</td>
<td>4</td>
<td>75</td>
<td>1985</td>
<td>R1</td>
<td>2</td>
<td>$60000</td>
</tr>
</tbody>
</table>

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### 2143

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>B202001</td>
<td>Windows</td>
<td>Exterior of site building</td>
<td>Multi pane single glaze Georgian</td>
<td></td>
<td>Poor. Firefighter sealant is cracked. Potential for water ingress leading to damage on distribution panel.</td>
<td>Replace window sealant</td>
<td>4</td>
<td>15</td>
<td>2000</td>
<td>R1</td>
<td>2</td>
<td>$11000</td>
</tr>
</tbody>
</table>

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### 2145

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
<th>Location and/or Area Serviced</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Project Type</th>
<th>Priority</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C102001</td>
<td>Interior doors</td>
<td>1st Level south east room</td>
<td>2 equipment doors on north and south of building with metal frames.</td>
<td></td>
<td>Poor. Equipment door has deformation and misalignment at the bottom. Potential for water ingress leading to damage on distribution panel.</td>
<td>Repaint, straighten and realign doors to ensure safe use.</td>
<td>4</td>
<td>35</td>
<td>1980</td>
<td>R1</td>
<td>2</td>
<td>$84000</td>
</tr>
</tbody>
</table>
11+ Years Detail

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Location</th>
<th>Component Description</th>
<th>Serial No</th>
<th>Observed Condition &amp; Repair History</th>
<th>Recommendations</th>
<th>Rating</th>
<th>Normal Life Expectancy</th>
<th>Actual Estimated Year of Acquisition</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>All the site building</td>
<td>Granite Surface Built up roof</td>
<td>TH00001354</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>Chain Hoist</td>
<td>SW Room Level 1 (Storage)</td>
<td>1 Ton Manual W/ Electric Wire Rope Hoist, C/W Electric Travel Trolley, Height Of Lift: 50 FT</td>
<td>TH00001360</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2000</td>
<td>F2</td>
</tr>
<tr>
<td>Crane</td>
<td>Within site building</td>
<td>1 Ton Manual W/ Electric Wire Rope Hoist, C/W Electric Travel Trolley, Height Of Lift: 50 FT</td>
<td>TH00001384</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2000</td>
<td>F2</td>
</tr>
<tr>
<td>Crane</td>
<td>Within site building</td>
<td>1 Ton Manual W/ Electric Wire Rope Hoist, C/W Electric Travel Trolley, Height Of Lift: 50 FT</td>
<td>TH00002192</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2000</td>
<td>F2</td>
</tr>
<tr>
<td>Crane</td>
<td>Within site building</td>
<td>1 Ton Manual W/ Electric Wire Rope Hoist, C/W Electric Travel Trolley, Height Of Lift: 50 FT</td>
<td>TH00001346</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2000</td>
<td>F2</td>
</tr>
<tr>
<td>Eye Wash Station</td>
<td>Basement Main Room NE</td>
<td>2&quot; Diatomite</td>
<td>TH00001310</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2005</td>
<td>F2</td>
</tr>
<tr>
<td>Sump Pump</td>
<td>Basement SW Room</td>
<td>TH00001379</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2005</td>
<td>F2</td>
<td>2</td>
</tr>
<tr>
<td>Dust Heater</td>
<td>Basement Main Room NE</td>
<td>50KW 3 phase</td>
<td>TH00001373</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2005</td>
<td>S</td>
</tr>
<tr>
<td>Dust Heater</td>
<td>Basement SW Room</td>
<td>50KW 3 phase</td>
<td>TH00001351</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2005</td>
<td>S</td>
</tr>
<tr>
<td>Dust Heater</td>
<td>Basement SW Room</td>
<td>50KW 3 phase</td>
<td>TH00001352</td>
<td>Good</td>
<td>Replace at the end of useful life.</td>
<td>8</td>
<td>25</td>
<td>2005</td>
<td>S</td>
</tr>
<tr>
<td>Interior Lighting</td>
<td>1st floor south east room</td>
<td>15 fixtures and incomplete. Poor to good. 18 fixtures are in good condition. Old incandescent fixtures were removed but the holes were not patched over.</td>
<td>Replace the holes were the old lighting was.</td>
<td>7</td>
<td>25</td>
<td>1990</td>
<td>S</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 43:

Reference(s): Exhibit 2B, Section D, Appendix A

With respect to the ‘Distribution System Plan Asset Management Review’:

a) Please provide the retainer agreement and any instructions UMS was given regarding its work.

b) Please provide a copy of the ISO 55001 document that UMS is using to compare Toronto Hydro against.

c) [p.7, 11] Please provide both, the median and average score for each of i) distributor only utilities, ii) transmission only utilities, iii) both, on the 11 ISO 55001 domains that UMS thought were relevant.

d) [p.8] Please provide a list of domains that the UMS did not believe were relevant.

e) [p.11] The Report states: “While these utilities were not specifically selected to represent the industry as a whole, as a consultancy who has performed scores of such assessments, UMS believes that the results are consistent with its qualitative view of asset management maturity across the North American utility industry.” What is the basis for this belief?
f) [p.18-21] For each of the domains that Toronto Hydro has been scored against, please provide UMS’ assessment of what Toronto Hydro would need to do to achieve level 3 maturity.

RESPONSE (PREPARED BY TORONTO HYDRO):

a) Please refer to Toronto Hydro’s response to interrogatory 1B-CCC-8.

RESPONSE (PREPARED BY UMS)

b) The ISO 55001:2014 standard was the basis for the comparison of Toronto Hydro. As this standard is copyrighted by the International Standards Organization (ISO), UMS Group cannot provide a copy. However, the document is publicly available for purchase from the ISO, the American National Standards Institute, and a number of other sellers.

c) There are 3 categories of Asset Management maturity assessment scores which UMS Group used in the Benchmark: Transmission-only, Distribution-only, and T&D-combined (e.g., utilities for which the asset management function is performed for both T&D). The median and average scores for each, as well as for all 14 utilities are included in Table 1 below.

Table 1: Breakdown of Asset Management Maturity Benchmark by Type of Business

<table>
<thead>
<tr>
<th>Unit</th>
<th>Transmission-only</th>
<th>Distribution-only</th>
<th>T&amp;D - combined</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Average</td>
<td>Median</td>
<td>Average</td>
</tr>
<tr>
<td>4.2 Understanding the needs and expectations of stakeholders</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.1</td>
</tr>
</tbody>
</table>
d) The following domains are those of the ISO 55001 standard which were not assessed:

4.1 Understanding the organization and its context, 4.4 Asset management system,
5.2 Policy, 7.2 Competence, 7.3 Awareness, 7.4 Communication, 8.2 Management of Change, 8.3 Outsourcing, 9.2 Internal Audit, 9.3 Management Review, 10.1 Nonconformity and Corrective Action, 10.2 Preventive Action.

e) The basis for UMS Group’s belief that the results from the sample of 14 utilities are consistent with and representative of the asset management maturity of the North American utility industry is our interaction and work with scores of these utilities. While not all of our engagements encompass a comparative assessment of asset management maturity, and therefore were not included in the benchmark, many of them include targeted work in asset management. We also interact with scores of other utilities, who may not be our clients, on a professional level at various conferences and forums. Both these targeted engagement and non-engagement
interactions provide us with insight into the maturity level of specific domains for a broad swath of North American utilities, which informs our qualitative view of asset management maturity.

f) The ISO 55001 Standard requires Competence (a maturity level of 3 in all domains) to be both demonstrated and documented, and the determination of Competence requires a complex, detailed assessment of a number of interrelated factors. This makes it difficult to provide a list of recommendations, which if made, would guarantee achievement of a maturity level of 3. However, in the interest of being responsive to the question, Table 2 below provides a high-level recommendation of what Toronto Hydro needs to be able to achieve level 3 maturity in the 11 assessed domains. In most cases, Toronto Hydro has in place, or in development, most of the capabilities required for achieving Level 3 maturity. However, validation of this maturity requires that a documented process be available for the assessor to evaluate. Therefore, the biggest gap is for Toronto Hydro to document its Asset Management objectives, strategies, and processes as required by the ISO 55001 standard.

Table 2: Achieving Level 3 Maturity

<table>
<thead>
<tr>
<th>ISO 55001 Section</th>
<th>Actions to Achieve Level 3 Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2 Understanding the Needs and Expectations of Stakeholders</td>
<td>Formally document the process for managing stakeholders in a Strategic Asset Management Plan (SAMP) along with the stakeholder analysis and signed approval of the decision-making criteria.</td>
</tr>
<tr>
<td>4.3 Determining the scope of the AM system</td>
<td>Formally document, as part of or linked to the SAMP, the criteria and rationale for determining which assets are part of the AM system; the AM Policy, and AM Objectives, the asset portfolio covered by the asset management system; and the boundaries/interfaces between the AM system and the other management systems used by Toronto Hydro.</td>
</tr>
<tr>
<td>5.1 Leadership and Commitment</td>
<td>Develop a formal SAMP, AM Objectives, and AM Performance Measures, so Leadership can confirm they are compatible with the organizational objectives, as well as that AM system supports delivery</td>
</tr>
</tbody>
</table>
of the SAMP. Develop a formal plan for communicating the asset management objectives and the importance of the AM system to stakeholders.

5.3 Organizational Roles and Responsibilities
Formally document roles and responsibilities for ensuring 1) creation and update of the SAMP, delivery of the SAMP; 2) the asset management system conforms to ISO 55001, and 3) creation and update of AM Plans.

6.1 Actions to Address Risks and Opportunities
Develop a formal AM Policy and ensure adherence to that Policy in Planning. In assessing risk, consider risks to the AM system in addition to risks to the assets or asset performance.

6.2 Asset Management Objectives and Planning
Create a SAMP which 1) identifies the process for designing, implementing and reviewing asset management objectives, and linking asset management objectives to organisational guidance and objectives; 2) documents the relationship between corporate guidance and directives to actions; and 3) describes how the AM objectives are monitored and the metrics to ensure performance against the objectives.

7.1 Resources
Document in the SAMP the resources required to implement and maintain the asset management system; the competencies required to implement and maintain the asset management system; and the roles and responsibilities to implement and maintain the asset management system. Establish a process to measure performance against the SAMP and track compliance.

7.5 Information Requirements
Create formal data governance and data management processes to ensure that the information requirements of the AM system have been adequately identified and that information is being adequately managed.

8.1 Operational Planning and Control
Develop and document a formal process for ensuring that the asset management system is being operated per the criteria established in the SAMP.

9.1 Monitoring, Measurement, Analysis and Evaluation
Document in the SAMP the process for setting quantitative and qualitative performance metrics including leading and lagging indicators; identifying patterns and behaviours that enable improvement activities; and ensuring alignment between performance indicators. Metrics should be established for asset management performance and asset management system performance.

10.3 Improvement
Establish, implement and maintain a formal process for determining opportunities and assessing, prioritizing and implementing actions to achieve continual improvement and reviewing their subsequent effectiveness.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 44:

Reference(s): Exhibit 2B, Section D, Appendix C

With respect to the ‘Toronto Hydro Asset Condition Assessment Methodology’:

a) Please explain how asset age is incorporated into the methodology.

b) Please explain how expected asset useful live is incorporated in the methodology.

c) Please provide a copy of the DNO Common Network Asset Indices Methodology
   [note: For the purposes of your response, it is acceptable to simply provide the
document by way of a web link]

d) [p.8] Please provide a copies of all documents provided to Toronto Hydro by EA
   Technologies related to: i) the recommended areas of improvement, and ii)
guidance and training documents.

e) [p.8] Did Toronto Hydro agree to all the recommended areas of improvement
   provided by EA Technologies? If not, please explain why not.

RESPONSE:

a) As explained on pages 7, 8 and 17 of Exhibit 2B, Section D, Appendix C, age is used to
calculate the Initial Health Score of an asset. The Initial Health Score is calculated
based on the asset’s age and expected life, taking into account its operational use and
operating conditions. The Current Health Score is determined by applying the observed or measured condition of the asset (i.e. the Health Score Modifier), as well as a Reliability Modifier, to the Initial Health Score.

b) As explained on pages 14 and 15 of Exhibit 2B, Section D, Appendix C, the Useful Life for an asset is used in combination with a duty factor and a load factor to calculate the Expected Life value for an asset. This value is then used to calculate the Initial Aging Rate, which is an input to the Initial Health Score discussed in part (a).

c) Link to the DNO Common Network Asset Indices Methodology:


d) Toronto Hydro is unable to provide training documents as training was carried out through a series of in person sessions. Guidance was provided through a series of conference calls as well as the documentation appended to this response listed below.

Documents provided to Toronto Hydro by EA Technology related to the recommended areas of improvement are attached to this response in Appendices A through Y, as listed below:

- Appendix A: Stage 1 Report - Asset Condition Assessment Project (September 2018)
- Appendix B: General Observations and Wider Concerns (January 2018)
- Appendix C: Review No. 21 - Air Insulated Submersible Vault Switches
- Appendix D: Review No. 20 - SF6 Insulated Submersible Vault Switches
- Appendix E: Review No. 19 - SF6 Pad Mounted Switches
e) For Appendices B through W, Toronto Hydro accepted EA Technology recommendations with specific exceptions. Please note that in all instances where recommended improvements were implemented or further discussed, EA Technology was in agreement with the modifications made to the models or accepted Toronto Hydro’s reasoning for not making any changes. In certain instances where Toronto
Hydro was unable to make the changes, the utility intends to explore the improvements further as it continues to refine and improve the calibration of the model. As stated by EA Technology in their September 2018 final report in Appendix A, Toronto Hydro “made sensible and constructive local modifications to model input data streams, and on occasion have also sought to adjust model architecture to reflect the differences of asset ownership and operation between Great Britain and Canada. These variations, and therefore the models developed by THESL, are in the opinion of EA Technology, consistent with the underlying objectives and principles of the CNAIM methodology.”

As part of two intermediate stage reports (Appendix X and Appendix B), in addition to individual model review documents, and the email thread attached as Appendix Y, EA Technology recommended areas of improvement that fall under the following themes:

- **Collars and Calibrations**: In the November 2017 report (Appendix X), EA Technology identifies concerns with the collars and calibrations used in Toronto Hydro’s models and states that Toronto Hydro has set its collars for some asset classes to trigger operational activities. Through the iterative reviews of the models and discussions with EA Technology, Toronto Hydro refined and adjusted collar values for these asset classes while taking into consideration the utility’s specific operating context. For the majority of the models and where suggestions and recommendations were incorporated to better reflect the asset condition, EA Technology found the adjustments to be in line with the underlying principles and objectives of the CNAIM methodology. With respect to Toronto Hydro’s legacy 4 kV Oil, KSO Oil, and Air Blast Circuit Breaker models (Appendices T, S, and F, respectively), the
parties did not come to a consensus. Toronto Hydro did not agree with EA
Technology’s recommendations to adjust the calibration values due to the
specific nature of these legacy assets.

- **Inspection data:** In every Model Review document (Appendix C-W, i.e. No. 1
  through No. 21), EA Technology recommended Toronto Hydro include
additional types of inspection data that it does not currently collect. It should
be noted that Toronto Hydro collects sufficient inspection data to rely on the
results from the ACA methodology. However, Toronto Hydro also notes that
the additional inspection data would likely enhance the accuracy of the results.
As part of continuous improvement, Toronto Hydro updates its inspection
forms and processes on a regular basis resulting in a more accurate picture of
the condition of its assets.

- **Asset definition:** EA Technology highlighted concerns with how asset health is
  applied to certain assets with multiple significant sub-components.
Specifically, switchgears are comprised of two separate components: a fixed
portion (i.e. the bus bar, cable termination, and other switchgear elements)
and a moving portion (i.e. the circuit breaker itself). EA Technology observed
that Toronto Hydro only generates a health score for the moving portion (for
example, refer to Appendix K, Air Blast Circuit Breakers). Where Toronto
Hydro considers the fixed components to be part of the switchgear, EA
Technology considers them to be a part of the circuit breakers. As noted in
Toronto Hydro’s response to interrogatory 2B-Staff-71, part (b), the utility
does not currently have the data necessary to calculate a health score for the
fixed portions of its switchgear. Furthermore, as noted in response to 2B-
AMPCO-39, part (b), in addition to using Health Scores in decision-making,
Toronto Hydro uses available maintenance records outside of the ACA algorithm to support tactical intervention and strategic investment planning. Adjustments and modifications integrated into the ACA models were made to suit Toronto Hydro’s operating context. Ultimately, EA Technology found that the local variations made to the models are consistent with the underlying objectives and principles of the CNAIM methodology.

- **HI Banding Definition:** EA Technology recommended that HI2 definition be amended which Toronto Hydro agreed to. An earlier version of the HI2 band defined it as “Minor deterioration in serviceable condition, may require assessment” as seen in Appendix Y (i.e. email thread). EA Technology suggested Toronto Hydro re-visit the definition to amend the “may require assessment” statement to either “assessment is to be undertaken” or “it is not”. Toronto Hydro amended the HI2 band definition to not require undertaking an assessment.

- **Calibration of Average Life:** EA Technology noted that Toronto Hydro’s expected (i.e. useful) life values for certain asset classes (Air Magnetic, Cable Chambers, Padmount Transformer, Underground Vaults, Vacuum Circuit Breaker, Network Transformers, Vault Transformers, and Air Blast Circuit Breakers) were broadly set and recommended dividing the asset populations into sub-groups (e.g. manufacturer/model data, duty, and counter readings) and reviewing the useful life values associated with these components. (See Appendices K, H, I, G, J, M, P, and F, respectively.) The values used in Toronto Hydro’s ACA methodology are aligned with 2009 Kinectrics report, “Toronto
Hydro-Electric System Useful Life of Assets”.

Toronto Hydro intends to update its useful life values in the future, and will explore opportunities to consistently gather and incorporate more granular information such as manufacturer/model data where appropriate.

- **Calibration of Duty & Counter Readings, Maintaining ACA Model Quality**

  *(Data Granularity and Quality)*: EA Technology suggested adding more granular data on the condition of assets by identifying sub-groups (e.g. manufacturer/model data, duty, and counter readings) in the ACA methodology. Toronto Hydro notes that this information can enhance the ACA methodology. As discussed in Exhibit 2B, Section D, Appendix C, page 13, more data can be collected from field inspections and will be considered as part of ongoing improvements.

- **Location Calibration**: EA Technology recommended Toronto Hydro incorporate more details for the Location Factor in the ACA methodology. As discussed in Exhibit 2B, Section D, Appendix C, page 13, Toronto Hydro defaults Location Factor to 1.0 and is currently engaged in developing condition criteria that will account for the effects of Toronto’s environment on the asset deterioration process.

- **Model Alignment**: EA Technology identified the risk of potential investment walls in future years for certain assets. EA Technology recommended regular reviews of the calibration values and, as noted in the points above, more granular asset data to be used as part of the ACA methodology. As part of

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1. Toronto Hydro has provided a copy of this report as Appendix A to its response to interrogatory 2B-SEC-38.
continuous improvement, Toronto Hydro updates its inspection forms and processes on a regular basis resulting in a more accurate picture of the condition of its assets. Toronto Hydro will continue to explore additional types of data to continuously improve the calibration and accuracy of its ACA models.

- **Condition Point Calibration and established Toronto Hydro practices:** As stated in Appendix J, EA Technology identified issues with how Toronto Hydro applied calibration scores for circuit breakers that are inspected and have deficiencies addressed at the same time in the field. As part of Toronto Hydro’s maintenance work (Exhibit 4A, Tab 2, Schedule 1-4), when deficiencies are identified on station circuit breakers through inspections, Toronto Hydro attempts to repair the asset immediately as assets are already de-energized for inspection purposes. As such, in the asset condition models, Toronto Hydro does not apply a calibration factor to increase the health score of the asset, but applies a reduced calibration score which results in lower health score (i.e. low health index band) as the deficiency was addressed at the time of inspection. After consulting with Toronto Hydro, EA Technology understood Toronto Hydro’s circuit breaker maintenance practices (specifically, the ‘Find It and Fix It’ philosophy). As previously stated, EA Technology supported that the variations were found to be in line with the objectives and principles of the CNAIM methodology.

As noted in the themes described above, Toronto Hydro plans to further refine and continuously test the methodology and its calibrations by validating the results against field data (i.e. inspections). Increased maturity will be achieved by exploring additional types of data to continuously improve the calibration and accuracy of the
results, developing condition criteria to account for the effects of Toronto’s
environment on the asset deterioration process. Toronto Hydro also plans to
consistently gather and incorporate more granular information such as
manufacturer/model data where appropriate.

EA Technology considers continuous improvement to be the natural progression of
models, as stated in their final report (see Appendix A): “We would expect that
following a period in which the new ACA methodology “beds-in” (matures) within the
organisation, existing asset inspection, maintenance, operational, and investment
policies and procedures may be revised in order to capture more asset specific data
and new opportunities to further improve over time as the benefits of this approach
are realised. EA Technology consider this to be a natural process in which models will
incrementally improve over time as the benefits of this approach are realised.”
Stage 1 Report - Asset Condition Assessment Project

Prepared for: Toronto Hydro Electric System Ltd

Project No: 116410
Document Version: V1
Date: 06 September 2018
Version History

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<th>Notes</th>
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<td>A. Harrison &amp; T. Pears</td>
<td>For review by THESL</td>
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<tr>
<td>06-Sep-2018</td>
<td>V1</td>
<td>A. Harrison &amp; T. Pears</td>
<td>Revision following THESL review</td>
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Final Approval

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Contents

1. Who is EA Technology? ................................................................. 1
2. EA Technology's Condition Based Risk Management (CBRM) Methodology ............. 1
3. Common Network Asset Indices Methodology ....................................... 2
4. Scope of involvement to date and length of contract ...................................... 3
5. Alignment of models and next steps .......................................................... 3
1. Who is EA Technology?

EA Technology originated in 1966 as the UK Electricity Council’s Research Centre (ECRC). Effectively a grant funded entity, ECRC’s role was to investigate new ways for people to use electricity and better ways for it to be distributed to customers. When the UK electricity industry was privatised in 1990, EA Technology ‘spun out’ of national ownership to become an independent organisation. The funding from the network operators and energy suppliers was progressively ramped-down and EA Technology made the transition to a commercial entity. In 2004 we became an employee-owned, innovation-focused organisation. Our headquarters are in Capenhurst in the Northwest of England and we have around 200 employees with offices in North America, Australia, Singapore, China and the Middle East.

Our customers include electricity generation, transmission and distribution companies, together with major power plant owners and operators in the private and public sectors. We are committed to providing our customers with innovative products and services, consultancy and training which deliver tangible benefits for their businesses enabling them to create safer, stronger and smarter networks for today and the future.

As a world-renowned provider of consultancy and technical services to the electricity industry, EA Technology has been intimately involved and at the cutting edge of technical, business, legislative and regulatory developments for 50 years. We have worked with over 60 utilities worldwide to improve their asset management capabilities, developing asset management strategies, implementing Condition Based Risk Management solutions and preparing asset data strategies as part of wider asset management strategy/policy development and implementation assignments.

2. EA Technology’s Condition Based Risk Management (CBRM) Methodology

Throughout EA Technology’s history, major areas of activity have included the study of degradation and failure modes and the development and application of condition assessment procedures for network assets. A lot of work has been carried out to build a detailed understanding of the relationship of equipment specification, maintenance regimes, environment and duty with degradation, performance and, ultimately, asset failure.

Since 2000, a major area of activity has been the development and application of condition-based processes to assist companies to manage ageing assets. The CBRM methodology is one of the major outcomes and it continues to evolve to meet specific requirements of electricity companies; to date, projects have been undertaken with over 40 network operators around the world.

A timeline showing the key milestones in the development of EA Technology’s condition based risk management methodology and products is shown in Figure 1.
3. Common Network Asset Indices Methodology

Within Great Britain, Distribution Network Operators (DNOs) are regulated by Ofgem, a government appointed regulator. Ofgem use an economic approach to regulation by agreeing to a suite of performance-based targets and operating licence contractual terms with DNOs over a series of "Price Control Periods". These targets range from metrics which reflect customer experience, overall network performance through to capital and revenue allowances.

The GB energy regulator Ofgem introduced regulatory reporting requirements for GB Distribution Network Operators for the regulatory period running from 2015 to 2023 (referred to as RIIO-ED1). RIIO (Revenue = Incentives + Innovation + Outputs). This marked a significant shift away from the previous RPI-X regulatory approach aiming to reduce costs within the utility sector to a more outcome-based regulatory reward system.

In order to facilitate these changes, a number of modifications to the requirements placed on network operators via their operating licences have been introduced. These include the requirement for DNOs to jointly develop a common framework such that DNOs adopt a common approach to the evaluation of asset health and criticality. DNOs are now required to report information on asset health and criticality using this common framework. This enables Ofgem to be able to make direct comparisons between each of the GB licence holders.

Most of the GB DNOs already had CBRM decision support tools developed in conjunction with EA Technology. Thus, CBRM was the logical starting point and EA Technology was invited to join the network operators' working group to develop the new common reporting standard, referred to as the Common Network Asset Indices Methodology (CNAIM or the Common Methodology). The output is similar to that from CBRM, but the CNAIM methodology is a simpler pragmatic approach that considers critical inputs for optimum results.

Figure 1  Timeline Showing EA Technology’s Condition Based Risk Management Activities
Following Ofgem’s approval of the methodology, EA Technology developed a suite of 25 CNAIM models and worked with each of the DNOs to implement the methodology and embed it within their organisations.

4. Scope of involvement to date and length of contract

EA Technology was engaged with Toronto Hydro-Electric System Limited (THESL) on 20th June 2017, to review the progress THESL had already made with the new ACA investment models. This involved remotely conducting a detailed desktop review of the ACA models for Submersible Transformers and Overhead 3-phase Ganged Switches, and a higher-level data input and calibration review of a further 3 asset class models.

Following this review, EA Technology recommended a series of training sessions, and the concept of asset lifecycle in the context of CBRM was introduced. This led EA Technology onto providing THESL with a detailed understanding of the underlying CBRM methodology in order that THESL were able to understand the CNAIM linkage between asset health, probability of failure and risk. THESL have also gained an understanding of what the key objectives for CNAIM are within the GB regulatory environment, the way in which performance is measured in the GB distribution network operators, and the way in which optimised financial investment programmes are created.

EA Technology has provided an ongoing support service role from the last quarter of 2017, up to the point where THESL’s new ACA models were frozen during quarter 1 in 2018. During this period, EA Technology has reviewed the types of input data THESL have used to develop the new generation of ACA models, considered the model outputs and calibration values based upon an ongoing dialogue between both organisations.

5. Alignment of models and next steps…

During the development of the new Asset Condition Assessment models produced by THESL, EA Technology have provided a series of training sessions which have explained the underlying philosophy and methodology in some detail. THESL’s level of enthusiasm and interaction has been consistently good, which demonstrates a high level of commitment, and a genuine willingness to develop both their asset management knowledge base and a superior way of working into the future.

The effort placed into both the interaction with EA Technology and the development of the new ACA approach appears to have delivered a solid foundation which can easily be built on. THESL have demonstrated a clear understanding of the concepts behind the GB’s Common Methodology, and this is evident by the way THESL have made sensible and constructive local modifications to model input data streams, and on occasion have also sought to adjust model architecture to reflect the differences of asset ownership and operation between Great Britain and Canada.

EA Technology has been party to a number of discussions in which local variations have been identified and subsequently agreed. These variations, and therefore the models developed by THESL, are in the opinion of EA Technology, consistent with the underlying objectives and principles of the CNAIM methodology.

As with the vast majority of projects of this nature, the initial development of ACA style investment decision support tools are often limited or restricted by the type, quality and/or volume of input data available to drive the calculation algorithms – and in this regard THESL can be regarded as one
of EA Technology’s typical customers. We would expect that following a period in which the new ACA methodology “beds-in” (matures) within the organisation, existing asset inspection, maintenance, operational, and investment policies and procedures may be revised in order to capture more asset specific data and new opportunities to further improve the ACA model capability.

EA Technology consider this to be a natural process in which models will incrementally improve over time as the benefits of this approach are realised.
Global Footprint

We provide products, services and support for customers in 90 countries, through our offices in Australia, China, Europe, Singapore, UAE and USA, together with more than 40 distribution partners.

Our Expertise

We provide world-leading asset management solutions for power plant and networks.

Our customers include electricity generation, transmission and distribution companies, together with major power plant operators in the private and public sectors.

- Our products, services, management systems and knowledge enable customers to:
  - Prevent outages
  - Assess the condition of assets
  - Understand why assets fail
  - Optimise network operations
  - Make smarter investment decisions
  - Build smarter grids
  - Achieve the latest standards
  - Develop their power skills
General Observations, & Wider Concerns… ACA Model Review

Introduction
THESL are currently undertaking an asset management led project to introduce a new approach to asset condition assessment into their organisation. THESL have identified a UK based methodology, referred to as CNAIM, (Common Network Asset Indices Methodology) as the basis upon which their new condition assessment practices could be based.

Over the last quarter of 2017, significant advances have been made in the design and development of THESL’s new ACA models. To date a total of 19 asset class models have been forwarded to EA Technology for review. This is a massive achievement! EA Technology have been impressed with the way in which, following some initial training, THESL have now embraced the CNAIM methodology and are able to design and create revised ACA models. Whilst THESL’s models are currently limited to asset health scores for the present day and health score estimates into the future, and do not include PoF, risk or interventions, it should be noted that there are not many organisations who have achieved this feat with so little external input - well done!

Document Scope
This document provides EA Technology the opportunity to draw upon its broader experience in the fields of both asset condition assessment and the investment modelling arena/space. The primary purpose of this document is to identify any areas for further consideration along with any points of concern which EA Technology consider may require improvement so as to aid the “defend-ability” of the revised ACA models and their outputs.

The points raised in this document are not intended as a criticism of THESL. Rather, these points are presented and raised through a genuine desire to assist THESL succeed, and embed the revised ACA model work into business as usual which hopefully, in due course, will obtain favour with the regulatory authorities.

These observations are intended to be constructive, and are based upon our experience of other appointed 3rd parties scrutinising similar EA Technology created deliverables for other customers around the world.

It is hoped that by raising these observations now, and applying a little time and thought at this point, that a lot of time, energy and resource can be saved further down the line should THESL find themselves in a situation whereby they need to justify stated investment needs or, worse still, rigorously defend financial authorisation applications!

Points for consideration / discussion...

#1 - Asset definition & Model Boundaries
Second only to the core philosophy which underpins CNAIM/CBRM, the next most important thing which needs to be made clear to any reader/asset manager/regulator is the definition of the asset being considered within each of the modelling assessments, and the boundary (and where appropriate the limitations) of any ACA investment model.
Within the review work recently undertaken, there have been a couple of examples of where RCM worksheets have stated what limitations the RCM review has been conducted to.

However, no explicit statements have been found in either:
- The ACA model design documentation
- The supporting ACA model documentation
- The Operating context documentation
  (which specifically relates to the ACA rather than RCM work)
- The ACA model output extracts/documentation.

This is a clear area for improvement!

**Why does this matter?**
With specific asset classes such as Transformers with tapchangers, limiting the assessment to only one main component may well affect the average lives, condition points, failure modes, risk calculations and ultimately the range of potential interventions which could be made available as model sophistication is enhanced and asset management capability improves.

Where limitations are applied, such as with the high-pressure air creation and distribution system associated with air blast circuit breakers. This may be considered reasonable as long as the management mechanism to ensure satisfactory condition and performance are maintained are clearly understood and has stated as dependants (i.e. the ABCB’s).

In the case of asset classes such as pad mounted transformers or withdrawable circuit breakers, limiting the focus of the condition assessment to just the moving portion of each device is likely to raise questions and THESL may struggle to defend this position.

**#2 – EOL criteria**
The next comment runs along a similar vein to the last, in that readers/assessors of the ACA models also need to understand the condition criteria or combination thereof which THESL would consider to represent “End of Life” (EOL). This observation applies to the majority of models whereby EOL statements are either missing or are not explicitly clear.

There is not always a clear separation between (tactical) routine maintenance and a more strategic process of capital investment in either complete asset replacement or partial intervention. This situation does seem to keep re-occurring, and is perhaps best explained when considering a multi-panel switchboard; for example a 10 panel HSS Eclipse, a 10 panel Siemens 8DA10, or a 10 panel Hawker Siddeley HG12.

Under what circumstances would THESL consider the replacement of the entire switchboard? The RCM study states what the proposed criteria would be against an individual moving portion, but not the entire switchboard. This can potentially lead to confusion between routine maintenance and capital investment.

Examples of this can also be seen within the civil assets reviewed. Cable Chambers and Vaults appear to be subject to specialist civil engineering assessments (and quite rightly so!) However, the output from this condition assessment is unclear as to whether any issues can be addressed by routine maintenance or significant capital investment will be required... Can these assets be saved?
Previous experience suggests that it is unlikely that a network operator would (or for that matter would be allowed to) replace a substation building upon discovering a door hinge in a bad condition – but, without providing this context, THESL may lead others into forming this impression! THESL should consider whether the data points used to determine asset health scores provide the correct blend of “tactical” and or “strategic”.

#3 – HI Banding Definition

Below is one example of a THESL Health Index Banding definition table.

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<td>HI1</td>
<td>New or good condition</td>
</tr>
<tr>
<td>HI2</td>
<td>Minor deterioration in serviceable condition, may require assessment</td>
</tr>
<tr>
<td>HI3</td>
<td>Moderate deterioration, require assessment and monitoring</td>
</tr>
<tr>
<td>HI4</td>
<td>Material deterioration, consider intervention</td>
</tr>
<tr>
<td>HI5</td>
<td>End of life, intervention required</td>
</tr>
</tbody>
</table>

Minor editorial changes to these definitions are not uncommon, and often take place to reflect “local dialects” or “regional terminology”. During the course of this project, the definition wording has been revised so as to provide more “clarity and certainty” about the meaning of each Health Index Band.

THESL may wish to revisit the HI2 definition to amend the “may require assessment” statement – either assessment is to be undertaken or it is not. It is suggested that THESL should add a standard activity to the regular model review process to look for and engineer out such anomalies.

#4 – Calibration of Average Life

The average life calibration values which have been set within the models have been broadly set in line with reports prepared for THESL by an external consultant. In almost every ACA model the approach THESL have taken has been to use the external consultant report as a broad brush.

Whilst THESL are in the early stages of developing condition assessment models the use of simple rules is acceptable. However, this calibration input could be regarded as “low hanging fruit”, and should be refined. Ordinarily, average life calibration is set by dividing the asset population into sub-groups. These may be by manufacturer/type, generation of device, decade of manufacture, insulation type etc.

Traditionally assets which are used to form electrical transmission and distribution networks tend to have long (40 years plus) service lives. It is also normal to experience a number of infant mortality failures due to either imperfect asset design, material selection or through external influences such as mal-operation, vandalism or the weather.

Average life calibration should be kept under regular review and be relevant to the asset population which remain in service at the time of review. A report which states that the average expected service life for a particular device type may be in the region of 30 years maybe useful when the assets are introduced to the system. However, after 45 years of active service, a stated value of 30 years is almost meaningless, and will be very difficult to defend when challenged – especially when the vast majority of the asset population remains happily in service!
#5 – Location Calibration

More “low hanging fruit” can be found in the area of locational data. THESL are understood to be working on this at the moment, so this will be brief...

Look to develop cause and effect relationships between attributes which relate to asset location. This may be in the form of a “10% expected service life reduction” in circumstances where assets are “exposed to road salt or prevailing wind direction”, or are subject to “poor ventilation” or perhaps “prone to flooding”?

Beware of “big data” approaches... Asset life reductions caused by “commissioned on a Tuesday, by a male engineer with blue boots”. It may be possible to get this out of a large enough data set, but this doesn’t make it true!

#6 - Calibration of Duty & Counter Readings

An ideal input into CNAIM/CBRM models which reflects circuit breaker or tapchanger asset duty can be found by using the counter readings taken directly from the device.

Whilst operation counter readings form the ideal basis for a duty factor, care should be taken to ensure that the counter reading does not double count against the asset age. It stands to reason that the older an asset gets, the larger the number of operations it will naturally be expected to have performed. Therefore, any counter readings should be compared upon a common basis; for example, an annualised operations count. This will enable devices and sites which work hardest to be identified.

This is an area of improvement which exists in THESL circuit breaker, tapchanger and air blast circuit breaker models.

#7 – Maintaining ACA Model Quality

During the Stage 1 model review process, EA Technology identified several errors within the ACA model equations and algorithms. The issues highlighted have subsequently been corrected. It should be noted that the high-level model reviews undertaken during Stage 3 of the project did not involve verification of any of the algorithms.

THESL have accepted that the models built during this rollout phase of the project have been vulnerable to poor input data quality – and there is little if any “work flow” protection currently within the models. THESL are predominantly working upon the basis that the source data will be of a sufficiently high enough quality that errors will not affect the process flow of any health score derivations – which is a risky route to take!

The financial value of the decisions which will potentially be made off the back of the ACA health score calculations are not insignificant. Therefore, EA Technology recommend that any programming code, equations or algorithms are made as robust as possible. As a minimum, all code should be able to deal with blank inputs and poor data quality in the future.

It is suggested that a “No Result” category should be created for assets that do not have a credible year of manufacture (i.e. YOM = 1900, or asset age is 117 years or 2017 years).

The use of simple rule sets, stock phrases and data dictionaries can help prevent data pollution, and make a contribution to the integrity of the ACA model outputs.
#8 - Model Alignment
The ACA models reviewed in Stage 1 of the project work from a mechanical point of view but the outputs appear to be "untested".

Health Score profile – Vault Transformers

Above are a couple of examples of health score profiles which could be regarded as either providing an untested view of THESL’s asset base or they paint a very serious investment need.

The ACA model review has uncovered a number of potential future investment walls, which give cause for concern and a clear priority order with which to focus future model development.

Implementing a number of the (low hanging fruit) calibration enhancements should help improve the picture presented by these health score profiles

Bad probably isn’t that bad

Equally don’t forget about the good profiles either... are they really that good?
#9 – Specification of THESL Equipment
During the review project, EA Technology have been concerned by some of the procedural, operational and asset management based issues which THESL have presented. One example of this is in relation to submersible transformers, where THESL are only expecting to obtain a useful service life of between 6 and 8 years for new “Cam-Tran” transformers.

THESL have observed that when subjected to moisture or partial submersion in water the speed at which corrosion takes hold, and the rate of external tank degradation takes place is completely unacceptable, and has been for a long period of time.

When challenged as to why this supplier is still used, THESL described a loose/informal partnership approach to issue resolution which has involved the adoption of the manufacturers’ recommendations to supply new devices with a stainless-steel transformer tank.

Certainly, this will reduce the rate at which corrosion takes hold, slightly. However, in EA Technology’s view will not have the effect of extending the expected serviceable life from 6-8 years to the 33 to 35 year expectation.

EA Technology would be happy and willing to explore this area in more detail with THESL, and would be delighted to offer our services to assist THESL with defining and specifying plant and equipment specification(s) and or provide our expertise into THESL’s procurement/purchasing procedures?

#10 – Equipment Selection
Following on from #9 above, THESL may also wish to consider the type of equipment that they employ, and the way in which it is used; for example, Air Insulated Pad Mounted Switches. THESL have specified and purchased switching devices which have a fault make capability of two operations. This leads to two separate lines of questioning:

1/ Is this considered to be appropriate given the devices intended network function? Could THESL consider/benchmark against the procurement and operational practices of other network operators to identify and adopt best practice?

2a/ Given the limitation of a maximum of two fault make operations, why are the number of operations carried out (normal and fault make) not recorded?

2b/ Does this situation, or a similar situation (perhaps to do with a total number of operations carried out?) exist with other network components within THESL’s power distribution system?

EA Technology would be happy and willing to explore this area in more detail with THESL, and would be delighted to offer our services to assist THESL with reviewing and improving existing defining and specifying plant and equipment specification(s) and or provide our expertise into THESL’s procurement/purchasing procedures? operational practice(s), data collection and recording processes, or undertaking an asset management system review?
#11 - Condition Point Calibration & established THESL practices

A number of models have been found to contain condition point calibrations for assets “in need of follow-up” which return higher factor values than assets with confirmed deficiencies.

Whilst EA Technology understand that this has been done in order to lower the overall health score for assets which have been added to future investment delivery plans; thereby elevating the health scores of assets with known deficiencies which do not currently feature on any intervention programme. This practice is not recommended as in the event that the investment delivery programme fails to deliver as planned, or regular ACA model review makes changes to model calibration, then there is a risk of assets with known deficiencies being lost within the noise of the broader asset population – and ultimately this may result in asset failures as they slip through the asset management net.

Calibration alignment in this way is regarded as not being within the spirit of the underlying philosophy/methodology, and would not be endorsed by any independent assessor.

One approach which could be considered more appropriate would involve calibrating the condition point as the underlying methodology intended, and then adding an additional field or two into the asset database/output results that flags assets which already appear in future investment plans. THESL may also consider it useful to identify within which future year any mediation is to take place. This way, regardless of how investment delivery programmes/functions perform, assets in poor condition remain on THESL’s asset management radar – and any business or regulatory led reporting can be taken directly from the ACA model system without the need for further manipulation.
Model Review #21 – Air, oil, Vacuum Insulated Submersible & Vault Switches ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 16-Jan-2018
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 13-Jan-2018):
- Submersible & Vault Switch Operating Context.pdf
- Air Insulated Submersible Switch Model Output.xlsx
- RCM Submersible Switches Worksheet.xlsx

Data Inputs

- The model contains 868 Switches.
- 114 devices have Unknown manufacturer.
- Location and Year of Manufacture Data appears to be well populated
- No Obvious data source provided to drive duty factor
- All switches are assumed to be of "integral" type – i.e. not withdrawable.
- 138 devices do not currently have an inspection date. These devices range in year of manufacture from 1968 to 2017, so the majority should have been through an inspection cycle.
- Phase barrier condition point included within dataset. This seems reasonable, however it is strange that this condition point is not mentioned in the RCM study.
- Other condition points detailed in the RCM study have not been included within the data set. Example – Operating Mechanism, Vacuum bottle condition, Operating Handle, Insulant condition. Consider inclusion?
- Measured condition states that Partial discharge condition is considered. No evidence to support this – No calibration table presented on "Measured Condition" tab or data included in "Raw Data" tab.
- Partial discharge inspection/testing is not included within the RCM documentation provided.
- Inclusion of Thermography test is considered good.
- RCM makes reference to insulant. Could the condition of oil filled insulant be considered?

- The range of condition points which have been included within the model could be improved. However, the way that condition points have been mapped appears logical and reasonable. See Areas of improvement

Model Calibration

- The operating context document states average life of 30 years. A "Normal expected life" (Raw data column V) has been set to 40 years.
- HI1 appears to be driven purely by age.
- No locational or duty calibration has been set.
- PD calibration tables missing.
Locational information included within the raw data, however, this is not used within the health score derivation. Environment - all assets described as "Outdoor". Is there a means by which some further differentiation can be made? See Areas for Improvement*

Evidence of the application of relative weightings between calibration points, these seem reasonable, and would be expected to be subject to regular review.

Evidence of calibration values <1.0 which would be expected with average life type models.

For improvement of how to use condition collars see Areas for Improvement

The applied calibration appears sensible, and is considered a good starting point for modelling. Please ensure that these values are kept under regular review.

**Model Outputs**

- The health score distribution profiles appear to be as expected given the input data currently being used to inform the model.
- Mappings between health score and health index appear to be working as expected.
- The model ageing mechanism appears to be functioning correctly.
- The asset population forms a nice spread over time which is positive from a replacement perspective – There are no investment walls currently on the horizon. This should not lead to complacency as revision of the input condition points is required.

**Specific areas of concern.**

1/ **Improving Input data.**

There is definitely scope to improve the condition points which are used to drive this model.

One example of how to improve input data and its associated calibration can be easily explained by considering "Internal Flood Water Stains". The inclusion of this point is considered good practice, however, there is a risk that the way in which the data point is defined and the way it has been calibrated make the model appear to be targeting a tactical action rather than a strategic view of the asset base.

If the data point were defined and calibrated as shown in the table below, then the differentiation would be clearer, and the same data could be used to inform both tactical and strategic points of view.

<table>
<thead>
<tr>
<th>Observed Condition</th>
<th>Calibration Factor</th>
<th>Condition Collar</th>
<th>Condition Input Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>No evidence of internal water stains or flooding</td>
<td>1</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Evidence of flood water stains or flooding – Not affecting electrical equipment</td>
<td>1.1</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Evidence of flood water stains or flood water – electrical plant has been submerged</td>
<td>1.35</td>
<td>10</td>
<td>6.5</td>
</tr>
<tr>
<td>Default / Blank</td>
<td>1</td>
<td>10</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The fact that evidence of flooding or water stains had been detected during inspection should drive a tactical response to do something about the drains, and this information could also be used to
modify the calculated expected life of plant and equipment as equipment working in a damp, humid, or location which has been identified as being prone to flooding is certain to affect the useful service life that would be expected from equipment in this situation.
Model Review #20 – SF6 Insulated Submersible & Vault Switches ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 15-Jan-2018
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 13-Jan-2018):
- SF6 Submersible_Vault Switch Operating Context.pdf
- SF6 Insulated Submersible Switch Model Output.xlsx
- RCM SF6 Submersible_Vault Switches Combined Worksheet.xlsx

Data Inputs

- The model contains 396 Switches.
- 115 devices have unknown manufacturer details. Model of switch Type Number does not appear to be stated.
- Inspection data is a little patchy, some attributes have between ~40 to 150 blanks in the inspection data.
- No partial discharge inspection data.
- No SF6 condition information presented – This can be condition assessed. Purity, moisture content and dew point are common condition indicators. Consider introduction?
- No operating mechanism data presented.
- Tank condition - assumed to be part of a corrosion deficiency
- No data point which reflects the level of duty has been included within the raw data. Consider operations count or identify units which are used asNormally Open Points, or switching nodes? Or the number of times fuses have been replaced following fault clearances?
- There is no mention of sites which have been, or are prone to drainage issues, and or flooding.
- The observed and measured condition points appear to have been put together without reference to the RCM study, and could be improved.
- No EOL condition criteria stated.
- The range of condition points which have been included within the model could be improved. However, the way that condition points have been treated (mapped and calibrated) appears logical and reasonable.

Model Calibration

- The operating context document states average life of 30 years (as per Kinectrics Inc. Report). A "Normal expected life" (Raw data column V) has been set to 40 years within the model.
- HI1 appears to be driven purely by age.
- No duty calibration has been set.
EA Technology (Capenhurst, UK). Jan 2018

• Locational information included within the raw data, however, this is not used within the health score derivation. Environment - all assets described as "Outdoor".
• RCM document states that there are both submersible and vault installations, could this be used as a differentiator?
• The use of health score collars appears to be reasonable within this model. At regular review ensure that the use of collars does not overrule the underlying methodology by forcing too many assets.
• Evidence of the application of relative weightings between calibration points, these seem reasonable, and would be expected to be subject to regular review.
• Evidence of calibration values <1.0 which would be expected with average life type models.
• The applied calibration looks sensible, and is considered to provide a good starting point for modelling. Please ensure that these values are kept under regular review.

Model Outputs

• The Health score profile appears to be consistent with the input data presented to the health score calculation engine, and the resulting profile shows a predominantly healthy asset profile.
• Assets in HI5 are due to gas leaks or corrosion deficiencies.
• The health score to Health Index mapping appear to work correctly.
• The ageing mechanism appears to work as expected.
• The rate of asset intervention and replacement looks to be achievable over the next 20 years. This should be kept under review as improvements are made to the input data, and as calibration values are refined.

Specific areas of concern.

1/ Data Collection / collation...
It appears that a number of asset inspection condition points have either:
- Not been inspected
- Not been recorded
Or
- Not made it through the asset management process to appear in the Raw data.

This may be as a result of the use of 3 inspection papers (each assumed to have different inspection frequencies) meaning assets have fallen through the cracks.

Please can you check what the root cause is? Different attributes appear to have different numbers of missing data points.

Consider review of the input data to ensure alignment with RCM study. Some key indicators appear to be missing – including partial discharge.

2/ EOL Criteria do not align with the detail provided within the RCM Study
Consider review, and the inclusion of partial discharge inspection
Model Review #19 – SF6 Pad Mounted Switch ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 22-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 21-Dec-2017):
- SF6 Pad-Mount Switch Operating Context.pdf
- SF6 Insulated Pad-Mount Switch Model Output.xlsx
- RCM SF6 Padmount Switches Combined Worksheet.xlsx

Data Inputs

- The model contains 399 Switches.
- Manufacturer, Year of manufacture and location data appears to be well populated.
- All switches are assumed to be of “integral” type – i.e. not withdrawable.
- 78 devices do not have an inspection date. This is probably due to the age of the assets? One asset YOM = 2007 has no inspection date has this been missed? Or are there data issues?
- Partial discharge survey inspection results included. This is positive, and helps contribute to the next point.
- RCM worksheet seeks to identify switchboards which have been exposed to moisture ingress or have been submersed.
  1/ Is the RCM activity the best way of achieving this? Evidence of condensation may not always be evident upon inspection.
  2/ Can this be included as a differentiator within the location consideration?
- RCM also makes reference to SF6 insulant – This can be condition assessed. Purity, moisture content and dew point are common condition indicators. Consider introduction?
- No data point which reflects the level of duty has been included within the raw data. Consider operations count or identify units which are used as Normally Open Points, or switching nodes?
- The range of condition points which have been included within the model could be improved. However, the way that condition points have been treated (mapped and calibrated) appears logical and reasonable.

Model Calibration

- The operating context document states average life of 30 years. A “Normal expected life” (Raw data column V) has been set to 40 years.
- HI1 appears to be driven purely by age.
- No duty calibration has been set.
- Locational information included within the raw data, however, this is not used within the health score derivation. Environment - all assets described as “Outdoor”.
  Is there a means by which some further differentiation can be made?
  Could this be driven by the housing condition?
Evidence of calibration values <1.0 which would be expected with average life type models.

- Evidence of the application of relative weightings between calibration points, these seem reasonable, and would be expected to be subject to regular review.
- The use of health score collars appears to be reasonable within this model. At regular review ensure that the use of collars does not overrule the underlying methodology by forcing too many assets.
- The applied calibration look sensible, and is considered to provide a good starting point for modelling. Please ensure that these values are kept under regular review.

Model Outputs

- The health score distribution profiles appear not to have been produced on a consistent basis. X-axis labels vary from profile to profile. This appears to be a presentation issue, but still needs to be fixed. This will also help confirm the health score/health index mapping and ageing mechanism.
- Reading between the lines (given the previous point), the health scores appear to be consistent with the view formed from reviewing the input data. The asset population is fairly young and in good condition. Where PD issues exist, asset health scores have been forced.
- The asset population is tightly grouped, and so it is important to gradually improve model granularity. Consider setting average lives by manufacturer, adding a simple duty measure such as NOP/diamond point/Switching node, and improving locational inputs e.g. flood zones, subject to salt spreading etc. This will help split the asset population.

Specific areas of concern.

1/ Model boundaries
The RCM document states the boundaries which have been imposed so as to complete the RCM study, however, no corresponding information has been provided which defines the ACA model boundaries, or statement to confirm that the same boundaries are being used.

Consider creating a suite of documentation which defines this for each ACA model.

2/ Selection of Input data.
There is definitely scope to improve the condition points which are used to drive this model. The inclusion of partial discharge is good, however, opportunities for condition points which directly relate to the condition of the switch internals (such as SF6 condition) have not been included.

With a fairly young asset base, which appears generally to be in a good state of repair, this is not something which needs to be addressed immediately, but should be seriously considered in the next year or so.
Model Review #18 – Air Blast Circuit Breaker ACA Model

Files provided by THESL for consideration (Emailed 20-Dec-2017):
- ACA_Airblast Circuit breaker_Model_V1.xlsx
- ACA_Airblast circuit breaker_model formulation.xlsx
- Air Blast Circuit Breaker_RCM worksheet.xlsx
- Air blast Circuit Breakers_Operating context.docx

Data Inputs

- The model contains 219 air blast circuit breakers. Year of manufacture and location data appears to be well populated.
- Raw data does not appear to have manufacturer/model information. Consider adding this as it may help provide additional granularity or a means of determining population sub-groups.
- The raw data does not appear to include any condition information which relates to the fixed portion of withdrawable type circuit breakers. See below...
- Measured condition points include contact resistance and insulation resistance deficiencies. However, there is no mention of partial discharge survey inspection results. Consider adding this in?
- Air blast circuit breakers work with very high pressure gas systems. The operating context and RCM worksheet quote operating pressures of between 150 to 260 PSI. Is THESL equipment subjected to pressure vessel testing? And/or pressure system certification? If so what high pressure system components are subject to this regime? – Our previous experience has found that this may extend/apply to compressed air (generation and storage) systems, air receivers, air reservoirs and any safety based relief or over-pressure control valves?

If applicable, these are important inputs to the ACA model as they can provide a condition report relating to pressure vessel wall thickness and integrity which does not appear to be explicitly spelt out within the documentation provided.

- Could measurements for the damping resistor be taken during intrusive maintenance? Could they be included within the measured condition points within the ACA model?
- The data points included within the ACA model appear to be reasonable and logical.
- Data mappings appear clear and transparent.

Model Calibration

- The operating context document states average life of between 30 to 50, and that the average asset life is 40 years. The model has been set with an average life of 45 years [Raw data column DG].
• HI1 appears to be driven purely by age and duty only 2 devices have a calculated expected life of less than 45. They are estimated at 37.5 based upon high operations count. The expected life calculation appears to be working as expected.
• Duty in terms of the number of operations should be converted to an annualised figure. Otherwise new assets will consistently score less than older units – this is already taken into account by considering asset age.
• Locational information included within the raw data, however, this is not used within the health score derivation. Environment - all assets described as “indoor”. Is there a means by which some further differentiation can be made?
• There does not appear to be any condition point calibration values which are <1.0. Values with a value of less than 1 would have the effect of improving derived health scores and would be expected within an average life calibration set. Consider review.
• Evidence of the application of relative weightings between calibration points, these seem reasonable. The factor values may be considered a little weighty by some, however, this is acceptable and would be expected to be subject to regular review.
• The use of health score collars would be considered to be more excessive than would typically be expected. Remember that the function of the ACA model is to provide a longer term strategic view of where assets lie within their lifecycle given a defined programme of inspection and maintenance – it is not intended to be a tactical activity dispatch tool. Review and consider the effects that the collars for “repaired - no follow up” collars are having, and then weight up the implications of their removal.
• Agree that collars for "partially repaired – Follow up" and "Yes" should be the same, and that attempts to categorise by severity of collars follows THESL’s existing practices. Note of caution: Such extensive use of collars may make the model "clunky", and has the potential to distort future health index estimation. This may result in an overly pessimistic view of the asset base in the future, and make future investment forecasting difficult.

**Model Outputs**

• The output health score distribution is considered to be unlikely to represent the true condition of the asset population. One reason for this relates to the fact that of the 234 assets with an age, 210 of them either meet or exceed the 45 year expected life.
• Of the 204 assets within the current health score band 5-6, only 12 have health score factors above 1.0. This indicates good observed condition. Consider a review of the average life calibration, and implementation of calibration values which are less than 1.0.
• Mapping between health score and health index profiles appears to work correctly.
• The ageing mechanism shows some asset spread over time, but this is limited by the current model calibration. The calculation appears to be working as expected.
**Specific areas of concern.**

1/ **Asset definition & Model architecture**
The operating context supporting document states that the compressed air system is out with the boundary of this ACA model analysis. However nowhere within the documentation provided for review is the definition of an air blast circuit breaker made, or the limitations of the ACA model clearly stated.

This model appears to have been conceived with an assumption of an air blast circuit breaker being a self-contained device/system (excluding supply air system) – analogous to a modern outdoor freestanding SF6 circuit breaker. Supporting documentation and RCM worksheet describes a number of the circuit breaker population as being withdrawable, and yet with the exception of item 24 on the RCM study (fixed shut off value) there appears to be no mention of the fixed portion of withdrawable devices within this model.

This discovery leads to concerns regarding THESL’s asset definition, and potentially the suitability of the ACA model’s architecture.

2/ **ACA Outputs & Model Calibration**
As stated above, the output health score distribution is considered to be unlikely to represent the true condition of the asset population, and this should prompt a calibration review.
Model Review #17 – Underground Vaults ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 21-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 20-Dec-2017):
- Underground Vaults Model Output.xlsx

Data Inputs

- No operating context document has been provided for review. This review has been conducted on the same basis as the cable chamber asset base.
- Raw data provided for 1,318 underground vaults.
- Raw data set is well populated. All assets have a year of manufacture, and only 22 assets have no inspection date.
- Locational information & Suburb data is included within the raw data – This is not taken in to account within the health score determination.
- All assets listed as being outdoors – can any differentiation be made between an good and a bad outdoor environment? Traffic routes? Salt exposure? Flooding area etc?
- Average life stated as 60 years.
- There appears not to be any builder/creator/manufacturer information within this data. Neither does the data confirm whether the installation is pre-cast or on-site poured. This prevents trending or trend analysis. Such fields maybe used to identify sub-groups in the future. Could "Entry type" be used as a simple way to add granularity?
- Data inputs included appear to be reasonable and logical. The only one that stands out is ducts – Do they form part of a vault? Or would they be treated as an asset class in their own right and just happen to be accessed via a vault/cable chamber?
- Data mappings appear clear and transparent.
- It is assumed that the wall/floor/roof deficiencies are identified by qualified structural engineering assessments. Is this true?
- Are there any measurements which could be included within this analysis. For example concrete integrity? Condition of reu-bars?

Model Calibration

- There does not appear to be any condition point calibration values which are <1.0. Values with a value of less than 1 would have the effect of improving derived health scores and would be expected within an average life calibration set. Consider review.
- Evidence of the application of relative weightings between calibration points, these seem reasonable.
- The use of health score collars has been correctly limited. Surprisingly, the collars applied for deficiencies with the structure of the vaults are set to 5.5. Consider review – would a value of 7 be more appropriate?
The calibration factors for hinges and vents would appear to be stronger than would be expected. This may be down to a difference in operational practice, and may be worth a short discussion via teleconference? Is this data point more tactical rather than strategic?

**Model Outputs**

- Mapping between health score and health index profiles appears to work correctly.
- The ageing mechanism calculation appears to be working as expected.
- The asset health score profile morphs over time.
- Given the input data that has been used to form this model, the output appears to be plausible, and broadly in line with THESL’s HI band definition.
- The health score profile shows a spike in the 5-6 category. This appears to be mainly driven by structural deficiencies and the associated health score collar. This spike gradually increases in size in future years, and over 270 assets are forecast to be in HI5 in years 10.

**Specific areas of concern.**

1/ No asset specific operating context document has been provided to support this ACA model.

2/ There is potential for future investment walls within this asset class. This will be made up of a combination of assets currently affected by the health score collars and newly detected structural deficiencies. Please include checks for these issues within regular ACA model reviews.
Model Review #16 – Cable Chambers ACA Model

Files provided by THESL for consideration (Emailed 18-Dec-2017):
- Cable Chamber_RCM_Operating context_V2.docx
- RCM Cable Chamber Worksheet_V2.xlsx
- Cable Chamber_ACA_methodology_V1.xlsx
- cable chamber_ACA-Model output_v2.xlsx

Data Inputs

- Raw data provided for 11,111 cable chamber assets.
- 1523 assets have no inspection date. A large proportion of these cable chambers would be expected to have inspection data due to their age.
- Year of manufacture dates range from 1909 to 2017. Early dates could be viable – check to ensure that there are no default data system entries.
- Condition assessment information is patchy. Example 3649 assets with no walls condition assessment data. This is sometimes attributed to a 10 year inspection programme, but it also appears that 2139 assets have not been inspected within the last 10 years, and are therefore out of inspection/maintenance policy.
- Average life stated as 60 years in Operating context document. Set to 65 years in the model.
- There does not appear to be a cable chamber type field within this asset data.
- There appears not to be any manufacturer information within this data. Neither does the data confirm whether the installation is pre-cast or on-site poured. This prevents trending or trend analysis. Such fields may be used to identify sub-groups in the future.
- Locational information included, all assets marked as outdoor. Suburb information is presented but does not appear to be used within the derivation. Would the fact that a cable chamber is situated within the TTC or road carriageway affect the expected service life through exposure to enhanced mechanical vibration?
- Two average lives stated within the operating context document. Lid at 25 years, chamber at 60 years. Do these components need separate health scores? See below...
- Data inputs included appear to be reasonable and logical.
- Data mappings appear clear and transparent.
- Other network operators also include Partial discharge survey results. PD surveys are routinely carried out with the initial operational assessments including gas testing before entry to a cable chamber – could this be considered within THESL?
Model Calibration

- Average life calibration has not been set as per operating context document.
- There does not appear to be any Observed condition point calibration values which are <1.0. Values with a value of less than 1 would have the effect of improving derived health scores and would be expected within an average life calibration set. Consider review.
- Evidence of the application of relative weightings between calibration points, these seem reasonable.
- The use of health score collars has been correctly limited, the applied collars appear appropriate.
- The model appears to be calibrated more towards the identification of partial intervention rather than End of Life. [See Model outputs point 3]

Model Outputs

- Mapping between health score and health index profiles appears to work
- The ageing mechanism calculation appears to be working as expected. The profile shows how the health score population will morph over time.
- Given the input data that has been used to form this model, the output appears to be plausible. That said, the volume of investment and intervention which appear to be required both now and in the future would give cause for concern. THESL may wish to consider a complete review of this model with some expert assistance.

Specific areas of concern.

1) Asset definition & Model architecture
The documentation which supports this model does not adequately define the boundaries of a cable chamber as an asset.

The operating context states that the average life of the cable chamber and the lid are significantly different. Whilst both the operating context and RCM document refer to cable ducts.

Consideration should be given to the architecture of the model, and the desired outputs. Are cable ducts part of a cable chamber? If so how are they identified and how are they linked back to the cable chamber? – do THESL require health scores for each component (lid, chamber, duct)?

On the assumption that ducts are excluded, it is acceptable to treat the lid as a sub-component of the chamber, and reference it as a condition point in its own right – as performed here. However, if the ducts are included then this adds an additional layer of complexity to the modelling!

It is for this reason (amongst a couple of others!) that civil assets are not included within the current CNAIM regulatory reporting within the UK. Work is currently being undertaken to see how substation buildings, electrical supports and buildings are to be reported, and cable basements and chambers are expected to be included within the next round of CNAIM development.
Model Review #15 – Pad Mounted Transformer ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 18-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 15-Dec-2017):
- Padmount Transformer Output.xlsx
- Pad-mount Transformer Operating Context.pdf

Data Inputs

- Model shows population of 6609 units.
- Raw data sheet presented looks well populated. There are a few obvious data errors which can easily be addressed with basic cleansing. An example of which is asset ages of 117 years, this looks like a default year of manufacture date of 1900.
- Manufacturer data available.
- Duty data present – this is good!
- All units described as being “outdoor”. This is fine for now, however, consideration should be given to improving this with other supplementary information. Location and Suburb data evident in raw data input table.
- Operating Context document states that “Average life is between 25 and 45 years, the average being 40 years”. Value of 35 has been implemented within the ACA model. It is unclear how this value has been determined.
- Model expected life calculation provides a range of expected lives from 25 to 38.9 years. This is broadly aligned with the operating context document.
- 684 assets have a HI1 which has been capped to 5.5.
- The asset condition points used within the model are presented, and the scoring mechanism similar to those seen previously. Scores and modified scores could be labelled more clearly.
- Partial discharge included – great!

- No RCM study provided for this asset type.
- See below issue with asset / model definition.
**Model Calibration**

- Average life calibration has not been set as per operating context document.
- Observed condition point calibration appears compatible with average life modelling, some calibrations <1.0, and some above. Consider applying similar rules to measured condition points.
- Observed condition points – application of relative weightings between condition of Tx / enclosure and presence of oil leaks.
- Measure condition – use of collars seems appropriate.
- Observed condition – perform regular reviews to ensure that the collars associated with oil leaks do not dominate too strongly.
- Calibration values could be made more granular. Consider setting values by identified sub groups, equipment generations or make/manufacturer etc. This would be expected to evolve over time.

**Model Outputs**

- Mapping between health score and health index profiles appears to work
- The health profile for this asset class is as expected. Slight spike at health score 4-5 band due to application of collars, which may not be necessary – THESL will have to form a view upon this.
- The ageing mechanism calculation appears to be working as expected. The profile shows how the health score population will morph over time.
- For the input data that has been used to form this output, the outputs appear plausible, and need to be kept under continual review to ensure that an accurate reflection of the actual asset base is kept.

**Specific areas of concern.**

1) **Asset definition & Model architecture**

The operating context document which accompanies this document states that these pad mounted transformers also include other additional major components. For example two position load break switches, and fuse systems, and none of these items appear to be taken into consideration.

There are a number of key considerations with pad mounted transformers with integral switches and fuse systems. One of the main influences would be whether such devices contain oil segregation, i.e. Are there separate chambers between main transformer and switch mechanisms? If not the asset life is heavily dependent upon the amount of arcing product contained within the transformer oil and this will be determined by the number of switching operations that have been carried out. There does not appear to be any reference to this within the ACA model.

This model also does not include any asset data which appears to have been collected from intrusive maintenance. Neither transformer oil condition, switch condition, fuse or fuse carrier condition or tapchanger condition have been included within the model architecture. Asset intervention would be expected upon the basis of these considerations.

To the best of my knowledge, this type of equipment does not exist within the UK, and has not been modelled directly by CNAIM. This model may require a significant amount of re-work!
Model Review #14 – Vacuum Circuit Breaker ACA Model

Files provided by THESL for consideration (Emailed 14-Dec-2017):
- Vacuum Circuit Breaker Operating Context_V2.docx
- Vacuum Circuit Breaker Worksheet_V2.xlsx
- Model_Formulation_Vacuum Circuit breakers.xlsx
- ACA_Vacuum Circuit Breaker_Moel_Output_V1.xlsx

Data Inputs

- Model shows population of 668 units.
- No Manufacturer/model information presented.
- Some questionable year of manufacturer data... YOM 1934, 1943, 1954?
- All indoor devices. Would it be possible to differentiate between good and bad indoor environments?
- Duty input is stated as using number of operations. Counter information blank for 617 of 668 records.
- Evidence of average life calculation being performed. One device has a 37.5 year expected life. It is unclear how the duty factor has been selected to drive this.
- These devices have been identified as being withdrawable, and yet there is no evidence of input data relating to the fixed portion. Consider adding this in.
- Could partial discharge survey inspection results be included?
- Inputs included are broadly aligned with RCM study. C5 survey form provides a better breakdown of inputs than A3. Which forms are being used.
- Input data mapping method is laid out logically, and is clear.

Model Calibration

- Average life has been set to 45 years. Only 12 devices are shown to be older, therefore the average life appears to be plausible for the population. This calibration value needs to be kept under regular review.
- This model contains very strong calibration settings, and high value collars. Strong calibration values would be expected for this type of asset to reflect the minimal intervention options typically available.
- No inspection values improve health scores. All calibration values are greater or equal to 1.0. THESL may wish to consider a review?
- Calibration values could be made more granular. Consider setting values by identified sub groups, equipment generations or make/manufacturer etc.
- Evidence of attempting to set calibration weightings to reflect the importance of each condition point in terms of condition assessment.
Model Outputs

- Mapping between health score and health index profiles appears to work
- The health profile for this asset class is as expected for a comparatively young asset population with a 45 year expected life.
- The ageing mechanism calculation appears to be working as expected, however, the lack of granularity makes the model output appear “clunky”.
- The outputs would appear plausible at this point. There are a couple of data quality issues to resolve, but this is to be expected.

Specific areas of concern:

1) Asset definition & Model architecture
Withdrawable circuit breakers comprise of two separate components a fixed portion and a moving portion. There is no specific reference made to the fixed portion of the circuit breaker. The THESL model has not been provided for review, and all documentation appears to concentrate upon the moving portions of circuit breakers.

2) Issues with Input data, inspection procedure & Model Calibration.
It appears that THESL have applied another sticking plaster...
Model calibration which reflects THESL’s practices of concentrating on assets with outstanding issues requiring follow up over assets with known issues is not in line with the philosophy or spirit of the CNAIM methodology.

There is a risk that in the event that capital delivery programmes do not deliver, assets with serious deficiencies will be “lost” in the health score results. Whilst EATL understands what THESL are doing, we will not endorse this approach – especially when the outputs of these models are potentially going to be used or regulatory reporting purposes.

Calibration review should be carried out to untangle these issues.

3) Partial discharge Testing
No mention of Partial discharge surveying or testing during routine inspection or testing. This would provide an important source of condition information which could be included within this ACA model.

4) This model has the potential to generate future investment walls
The importance of regular calibration reviews cannot be overstressed for this model. With such aggressive calibrations future health score movements will be rapid as the combination of age and deterioration contribute more to the output. At the moment the asset population appears as though it will remain as a tight pack and will gradually jump from one end of the health score scale to the other. Long term planning with this model may prove to be difficult.

Consider:
- Adding input data granularity
- Setting up regular model reviews
- bringing calibration values more into line with CNAIM.
Model Review #13 – Air Magnetic Circuit Breaker ACA Model

Files provided by THESL for consideration (Emailed 12-Dec-2017):
- AIRMAG_ACA_MODEL OUTPUT.xlsx
- AIRMAG_ACAModel_Formulation_V2.xlsx
- AIRMAG_OC_RCM_V2.docx
- AIRMAG_RCM_Worksheet_V1.xlsx

**Data Inputs**

- Model shows population of 556 units.
- Locational data field has been included within the inputs. This remains unclear exactly what this represents, and it does not appear to be included within the health score calculation.
- All units shown as being indoors. Is there room for development by considering what a good or bad indoor environment looks like? Or are all buildings/enclosures in perfect condition?
- Duty input is stated as using number of operations. Is it possible that there is data pollution in this field? Looks like a mixture of counter readings, calculated values and inspection codes.
- Expected service life calculation appears to work correctly.
- Could partial discharge survey inspection results be included?
- No evidence of input data relating to the fixed portion of these devices.
- Inputs included are broadly aligned with RCM study.
- Input data mapping method is clear and transparent.

**Model Calibration**

- Average life has been set to 45 years. 282 units above this value. The average looks plausible for the population, however only if you work on the assumption of a very wide spread of actual service lives. Consideration should be given to this calibration value.
- This model contains very strong calibration settings, and extensive use of collars.
- All calibration values are greater or equal to 1.0, i.e. no inspection values improve health scores. THESL may wish to consider this at review.
- Calibration values could be made more granular. Consider setting values by identified sub groups, or make/manufacturer etc.
- Evidence of attempting to set calibration weightings to reflect the importance of each condition point in terms of condition assessment. This is positive – but quite aggressively set.
Model Outputs

- Mapping between health score and health index profiles appears fine
- The health score has a large asset population residing in the 5-6 band. This appears to be made up of old assets in a reasonable condition.
- The ageing mechanism calculation appears to be working as expected.
- The model output would concern me as an asset manager, as there is a clear investment wall to be jumped in future years 7 to 10. This highlights the need for more granularity in the way assets are considered, input data and form of health score profile.

Specific areas of concern.

1) Asset definition & Model architecture
The THESL model has not been provided for review, and all documentation appears to concentrate upon the moving portions of circuit breakers. Withdrawable circuit breakers comprise of two separate components a fixed portion and a moving portion. There is no specific reference made to the fixed portion of the circuit breaker. This may not seem very important now however, it will become important in the future – especially as in time THESL are likely to consider partial interventions and refurbishments!

2) Issues with Input data, inspection procedure & Model Calibration.
It appears that THESL have applied another sticking plaster...
Model calibration which reflects THESL’s practices of concentrating on assets with outstanding issues requiring follow up over assets with known issues is not in line with the philosophy or spirit of the CNAIM methodology.

There is a risk that in the event that capital delivery programmes do not deliver, assets with serious deficiencies will be “lost” in the health score results. Whilst EATL understands what THESL are doing, we will not endorse this approach – especially when the outputs of these models are potentially going to be used or regulatory reporting purposes.

Calibration review should be carried out to untangle these issues.

3) Partial discharge Testing
No mention of Partial discharge surveying or testing during routine inspection or testing. This would provide an important source of condition information which could be included within this ACA model.

4) Evidence of future investment wall years 7 to 10.
This highlights the need to further split the asset population “pack”. Consider providing asset input data upon a more granular basis. Consider forming logical sub-groups examples of which could include manufacturer and type/model or pre XXXX and post XXXX (where XXXX is a year of manufacture).
Model Review #12 – Network Protectors ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 19-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 11-Dec-2017):
- Network Protectors Operating Context.pdf
- RCM Network Protectors Combined Worksheet.xlsx
- Network Protector Output Model.xlsx

Data Inputs

- Model shows population of 1688 units.
- Raw data sheet presented is well populated.
  - only 20 assets without an inspection date
- There are a few obvious data errors
  - 20 assets shown with a year of manufacture date of 1900.
- Manufacturer data available.
- No duty input – although operating context document states that devices have operation counters.
- 191 devices are stated as being situated indoors. No differentiation between indoor or outdoor situations evident or account of good or bad environments. This would only be considered acceptable in the event that all devices operate in identical conditions. Consider adding additional granularity if required.
- Operating Context document states that “Average life is 35”. A value of 30 has been used in the model. It is unclear how this value has been determined.
- The data inputs appear to be reasonable and straight forward to collect. Input mapping appears reasonable. The RCM document outlines more condition points which could be included within the model build. Consider adding IR test results?
- This is the first model in which THESL have set a reliability factor.

Model Calibration

- Calibration values could be made more granular. Consider setting values by identified sub groups, equipment generations or make/manufacturer etc. This would be expected to evolve over time.
- Average life calibration has not been set as per operating context document.
- Observed condition point calibration appears compatible with average life modelling, some calibrations <1.0, and some above.
- Evidence of relative weighting application between observed condition points.
- Observed condition – Use of collars set at 4 for external condition is probably not necessary. Consider whether this is really needed? Or whether this could be achieved by setting different average lives for different generations of network protector.
**Model Outputs**

- HI1 is being purely driven by asset age.
- Mapping between health score and health index profiles appears to work.
- The health profile for this asset class is as expected. Slight spike at health score 4-5 band due to application of collars, which may not be necessary – THESL will have to form a view upon this. And a larger spike in the 6-7 range which relates to the older generation of assets which exceed the stated expected life and have been captured by the reliability modifier factor/collar.
- The outputs appear to be in line with the way in which THESL consider the different types of network protector. However, 529 assets within the population of 1688 have been affected by health score collars. Evidence of Vented network protectors in good condition being caught by collars of 4, which would be likely to be challenged.
- Evidence of why the reliability factor has been set for all but one asset sub-type is also likely to be questioned.
- The ageing mechanism calculation appears to be working as expected. The profile shows how the health score population will morph over time.
- The model outputs appear to align with THESL’s current thinking, and it is clear that a substantial volume of intervention looks as though it is going to be required within this asset population with years to come. Whether this work volume is manageable or represents an investment wall is for THESL to determine.
- Regular calibration reviews could help mitigate against investment walls. EATL can also assist with replacement prioritisation if required.

**Specific areas of concern.**

There are no specific areas of concern.
Model Review #11 – Network Transformers ACA Model

Review Location: EA Technology, Capenhurst, UK
Review Date: 21st December 2017
Reviewer: Tracy Pears / Andi Harrison

Files provided by THESL for consideration (Emailed on 11th December 2017):

- Network Transformer Model Output.xlsx
- Network Tx. + HV Switch Operating Context.pdf
- RCM Network Tx. Switch Combined Worksheet.xlsx

Data Inputs

- The model shows a population of 1823 network transformers.
- Only one unit with a year of manufacture of 1900. This field appears well populated and has good data quality.
- 14 units have no inspection date. Earliest inspection date recorded is May 2012.
- 291 transformers have a utilisation of either "0" or “Blank”.
- Extensive use of free text in raw data – this is a wider point, however consider the use of stock phrases to make more automated analysis possible.
- Duty driven by transformer utilisation – this is good.
- Transformer situation is well populated.
- Input data contains condition points which relate to the primary switch unit. This is positive. The input appears to relate to ability to operate rather than condition of the switch – is this the most appropriate line of questioning? Input is valid – Just wondering about the potential intervention, can the switch be replaced or does the entire transformer need to be replaced?
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- Input data contains condition points which relate to the primary switch unit. This is positive. The input appears to relate to ability to operate rather than condition of the switch – is this the most appropriate line of questioning? Input is valid – Just wondering about the potential intervention, can the switch be replaced or does the entire transformer need to be replaced?
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- No evidence of input data relating to the tapchanger. Consider whether this is obtainable and will provide a meaningful insight?
- Consider the addition of oil analysis, DGA & Furan chemistry?

Model Calibration

- The expected life has been set at 35 years. Model calibration shows a range of calculated expected lives from 25 to 38.89 years. This appears reasonable, but perhaps a little lower than would be typically expected. Consider setting the average life by manufacturer or some other easily defined population sub-group. Ensure processes exist to keep this model parameter under regular review.
- Calibration values appear compatible with an average life model type. Values less than 1.0 evident for a number of condition and duty points. All calibration factors look reasonable.
- The calibration values have been set separately for external condition and oil leaks depending on the location of the deficiency. The factors and corresponding collars for oil leaks from the base of the tank have been set to have the most significance and this seems to be a reasonable approach.
• There are a number of calibration collars set for both measured and observed condition points. These appear to have been considered carefully and appear to align with what we know about THESL practice. Collars appear reasonable, and their use in this instance is acceptable at this point in time. Please ensure that the application of these collars does not overpower the underlying methodology – add this check to the activities carried out during regular review. How many assets are forced vs how many are calculated via the methodology. If too many assets are being forced then consider removing some of the lower order collars.

**Model Outputs**

• The health score profile is as expected for an asset population that is comparatively young, with some defects detected.
• There are more assets in need of intervention than would be imagined would be desirable. Does this align with THESL's perception of the current asset base?
• The model health score to health index mapping appears to work correctly.
• The model ageing mechanism appears to be working as expected.
• The model outputs appear to suggest that a modest investment wall could start to form in year 7 in band 5-6, this spike would then approach HS=7 between years 10 and 15.
• This investment wall could be dispersed by providing more granularity for example providing average life inputs by manufacturer etc.
• The use of collars as implemented within this model may result in the formation of an investment wall earlier than the model currently suggest. This should be kept under regular review. Please add this activity to those carried out at regular review intervals.

**Specific areas of concern**
Model Review #10 – Wood Poles ACA Model

Files provided by THESL for consideration (Emailed on 11th December 2017):

- Wood Poles Model Output (Updated).xlsx

Data Inputs

- The model includes five observed condition inputs, with 'pole void' replacing 'visual pole condition' since the Stage 1 review. This seems reasonable and, although visual pole condition could still be included in the model, there is the potential for an element of 'double counting' with the other condition inputs.
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- Since the Stage 1 review, an additional measured condition modifier (shell thickness) has been incorporated into the model. Provided that the readings are believed to be accurate, this is regarded as a reasonable addition.
- No environmental influences or duty components have been included in the model which is in line with the CNAIM OHL Support – Poles models.
- Over 33,000 of the poles have no inspection year and, hence, no condition data; around 40 per cent of these are more than 10 years’ old and would be expected to have undergone inspection. It is also noted that there is no inspection data from 2017.

Model Calibration

- The expected service life has been set at 45 years for all assets. The average age of the wood pole population is 28 years and just over 25 percent of the assets are over 45 years old; hence, the expected service life used in the model is probably reasonable. If THESL are aware of any significant differences between different species of wood or different manufacturing periods, these could be incorporated into the model in the future.
- The observed condition settings have been set to reflect the relative significance of the various deficiencies in terms of THESL's intervention / replacement activity. The application of observed condition caps and collars are considered to be appropriate.
- The setting of the pole decay / deterioration modifier has been corrected since the original review and the definitions and settings are consistent. The factors have been set lower than those used in the CNAIM OHL Support – Poles models; the factors could be increased, but the pole decay / deterioration collar setting of 8 should capture those poles where the residual strength is below an acceptable level and intervention is required.
- The calibration settings for the shell thickness modifier are considered to be reasonable.

1 Wood Poles Model_Output.xlsx (provided by THESL on 20 October 2017)
**Model Outputs**

- Since the initial review, the model has been extended to include the estimation of future health score and health index. The future health scores estimated by the model align with the application of the ageing mechanism (forecast ageing rate and ageing reduction factor) as applied in CNAIM.
- The current health index profile indicates that 660 wood poles (less than 1 percent of the population) have reached end-of-life; i.e. a health score ≥8 which seems reasonable. However, around a quarter of the assets are in the HI 5-6 and 6-7 bands which broadly corresponds to the number of assets that are older than the expected service life of 45 years. Increasing the average life for older wood poles and / or including some of the missing inspection results for older wood poles should allow more differentiation between assets and, hence, better inform intervention activities.
- The future year health score predictions indicate that around 10 percent of assets have reached end-of-life (health score ≥8) in 5 years' time. This is driven by the ‘wave’ of assets HI 5-as described above and is probably an overly pessimistic representation of the wood pole population.

**Specific areas of concern**
Model Review #9 – SF6 Circuit Breaker ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 11-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 07-Dec-2017):
- SF6 CB_OC_RCM_v4.docx
- SF6 CB ACA Model considerations.docx
- SF6_RCM Worksheet_V4.xlsx
- SF6_ACAMODEL OUTPUT.xlsx
- Model Formulation_CBSF6.xlsx

Data Inputs

- Model shows population of 160 CBs. Operating context document contains both indoor (~160) and outdoor types (~25). No evidence of outdoor equipment in model data set.
- Operating context documents & RCM study mentions operations counter – This would make an ideal input with which to drive the duty factor. Examples of other alternatives could include CB function (i.e. line, bus tie, transformer) or specific circuit breaker features such as fitted with active auto-reclosing.
- Evidence of some questionable input data / data quality issues. Circuit breaker age 11 years old has completed over 9800 operations?
- Locational information presented as data inputs. It is unclear what these values represent, and they do not appear to be used within the health score derivation.
- No evidence of input data being used from the fixed circuit breaker portion.

Model Calibration

- It is unclear how the average life has been determined from the information presented for this review. It is assumed that this has been set on advice from a previous Kinetics report? An expected average service life of 45 years for this asset class does not seem unreasonable for this type of asset class – however it is important to keep this under regular review.
- The RCM document states a number of different circuit breaker manufacturers – consideration should be given to providing calibration values against each manufacturer/model.
- Evidence of attempting to set calibration weightings to reflect the importance of each condition point in terms of condition assessment. This is positive.
- Serious issues with calibration settings – see below.
- Condition defects relating to Insulation resistance and contact resistance both lead to asset replacement. However, the calibration collars are different... Why?


Model Outputs

- Mapping between health score and health index profiles appears to work well.
- HI1 is purely driven by age.
- Condition calibration appears aggressive.
- The model health score profiles seem to reflect this.
- The ageing mechanism calculation appears to be working as expected.
- THESL would need to provide a comprehensive commentary to accompany the outputs of this model in order to provide reassurance as to the credibility of this model output. Whilst the profile looks credible I would need to be convinced that it truly reflects the actual asset base it is meant to represent.

Specific areas of concern.

1) Asset definition & Model architecture
The THESL model has not been provided for review, and all documentation appears to concentrate upon the moving portions of the SF6 circuit breaker. Withdrawable circuit breakers comprise of two separate components a fix portion and a moving portion. There is no specific reference made to the moving portion of the circuit breaker, which leads to concerns regarding the model architecture, and the modelling asset definition.

It remains unclear whether any specific condition assessment for the fixed portion has been included within the health score derivation. A brief call to resolve/discuss this issue maybe the easiest/fastest way to resolve this issue.

2) Issues with Input data and inspection procedure.
It is not appropriate to calibrate investment models based upon a CNAIM methodology to reflect highlighted issues with source input data. This is not acceptable, and MUST be addressed as a matter of priority. The root cause of the problem here appears to be with the way asset data is collected and recorded and not with CNAIM modelling approach, philosophy or methodology.
Sticking plaster solutions are not acceptable within this arena!

3) Partial discharge Testing
No mention of Partial discharge surveying or testing during routine inspection or testing. This would provide an important source of condition information which could be included within this ACA model.
Model Review #8 – Vault Transformers ACA Model

Review Location: EA Technology, Capenhurst, UK
Review Date: 8th December 2017
Reviewer: Tracy Pears

Files provided by THESL for consideration (emailed on 6th December 2017):
- Vault Transformers Model Output.xlsx

Data Inputs

- The model includes three observed condition inputs: external condition of tank (corrosion), oil leaks and connections condition. The inspection form responses used to derive the three condition inputs are the same as in the submersible transformer model and are considered to be appropriate.
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- No measured condition inputs have been included in the model. It is not known whether THESL collect any measured condition inputs, such as partial discharge or temperature readings, which could be used to inform the model outputs.
- No environmental influences have been included in the model; i.e. the Location Factor is set to unity for all assets. This is reasonable provided that all of the assets are situated in similar indoor environments.
- Transformer duty has been included in the model based on the maximum percentage utilisation of the asset under normal operating conditions. This is in line with the approach in the Common Methodology.
- The condition fields within the model are well populated (around 95 percent) and the duty inputs are around 80 percent populated.
- Around 2 percent of the assets have year of manufacture dates of 1900 and 1901 which are presumably system default dates. This is a minor data quality issue that does not significantly affect the model results and can be remedied as part of a wider data cleansing and validation exercise.

Model Calibration

- The expected service life has been set at 35 years for all asset types. As the average age of the vault transformer population is 30 years and over one third of the assets are more than 35 years old, this figure seems to be too low. It is suggested that the service life is increased for different subsets of the population; this could be as straightforward as setting the service life depending on the date of manufacture (e.g. pre- or post-1980 as in the CNAIM transformer models) or setting the service lives by manufacturer/model. Inclusion of this additional knowledge would add more granularity to the results and better inform asset intervention/replacement programmes.
- The calibration values have been set separately for external condition and oil leaks depending on the location of the deficiency. The factors and corresponding collars for oil leaks from the base of the tank have been set to have the most significance and this seems to be a reasonable
approach. The condition collars have been set to align with THESL's intervention / replacement activities and are considered to be appropriate.

**Model Outputs**

- The current health index profile shows 35 percent of the assets in the HI 4-5 band. This broadly corresponds to the number of assets that are older than the expected service life of 35 years (the majority of these are in good condition and, hence, are in the HI 4-5 band rather than the HI 5-6 band) and is unlikely to be providing an accurate reflection of the asset health of the population of vault transformers.
- The future health scores estimated by the model align with the application of the ageing mechanism (forecast ageing rate and ageing reduction factor) as applied in CNAIM.
- The future year health score predictions indicate that 312 assets will have reached end-of-life (health score \( \geq 8 \)) in 5 years' time. Although this appears to be reasonable, there is a large 'wave' of assets that have already exceeded the expected service life and are slowly moving through the health index bands and a significant replacement programme is predicted in around 10 years' time.

**Specific areas of concern**
Model Review #7 – SCADAMate R2 Switches ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 08-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 06-Dec-2017):
- RCM SCADAMATE R2_WORKSHEET.xlsx
- SCADAMATE (PARTS) Operating Context_V1.docx
- SCADAMATE_R2_ACA_Model formulation
- SCADAMATE_R2_ACA_MODEL OUTPUT.xlsx

Files provided by THESL for consideration (Emailed 07-Dec-2017):
- SCADAMATE_R2_ACA_MODEL OUTPUT_V4.xlsx

**Data Inputs**

- The model shows 1091 assets, however a number of condition assessment data fields are only around 10% populated. This will have a significant affect upon the model outputs.
- The input data shown in the model formulation document broadly aligns with the asset inspection points outlined within the RCM maintenance document. The condition points are considered appropriate for this asset class.
- Errors in the age calculation were noted in the model output documents emailed on 8th Dec 2017.
- The asset data point combination appears to be transparent and logical.
- The model contains some locational information; however, it is unclear what this is, or what can be determined from the information presented. (raw data, columns I&J). This location data does not appear to relate to harsh environments or locations which are subject to high levels of dust pollution or road salt.
- The input data appears to suggest that SCADAMate R2 devices are all situated Indoors – This seems unlikely?
- There is no real information to drive the duty factor module. Would it be possible to include the number of operations carried out annually? Or perhaps either network position or switch function e.g. Auto-reclosing? Normally open point? or nodal switching point?

**Model Calibration**

- It is unclear how the average life has been determined from the information presented for this review. It is assumed that this has been set on advice from a previous Kinetrics report? An expected average service life of 45 years for polymer insulated SF6 line gear which contains electronic controls would not be considered likely within the UK. Consideration should be given to reviewing this figure.
- HI1 is purely driven by asset age. Consider sourcing and using more granular input data to drive the location and duty derivations.
- Condition point calibration appears more suited to a maximum average life based model, as all calibration values are set to a value of 1.0 or greater. i.e. no values will improve the calculated asset health score.
Whilst the relative importance of different asset inspection attributes are reflected in the range of condition point calibration setting, the applied calibration setting for this asset category could be described as being “heavy”, (i.e. containing large factors of 1.5 to 1.9). However, given the limited range of practical interventions which may be applied to this type of “maintenance free” device, the application of a weighty calibration is not considered unreasonable given common practice regarding the way in which similar devices are operated, maintained and managed.

The use of health score collars seems appropriate.

**Model Outputs**

- The health score profile produced by this model reflects the fact that the asset population is generally young, and there is not a great deal of condition information to separate assets within this asset class out.
- EA Technology would describe this model as being “Clunky”, (i.e. all of the assets are tightly grouped together and currently they are likely to move across the health score scale together).
- Whilst the asset base is still comparatively young, and the health scores are low, this does not matter so much. However it is important that the range and input data is improved so that the asset “pack” is split as the assets mature. This model should be kept under regular review to ensure that this evolution takes place.
- Mapping between health score and health index profiles appears to work well.
- The ageing mechanism calculation appears to be working as expected.
- From a functional point of view this more appears to be working correctly.

**Specific areas of concern.**

1) Low volumes of condition/inspection information – this should be monitored over time. Would it also be appropriate to include partial discharge and or thermography into the inspection / survey / condition point results?

Devices like the PD Hawk, or Ultra Tev with parabolic dish could provide a source of important condition information. Please contact EA Technology for more information if required.

2) Calibration settings are weighty and more suited to maximum average service life rather than average service life. Consideration should be given to reviewing these once more inspection data has been acquired.

3) The results produced by this model have not been demonstrated to represent an accurate reflection of the actual asset population.
Model Review #6 – Air Insulated Pad Mount Switches ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 07-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (Emailed 05-Dec-2017):
- Air Insulated Pad Mount Switch Model Output.xlsx
- Pad-Mount Switch Operating Context.pdf
- RCM Padmount Switches Worksheet.xlsx

Data Inputs

- The input data shown in the model formulation document aligns with the RCM maintenance study undertaken within THESL, and the condition points are considered appropriate for this asset class.
- The RCM study asks for procedural change to ensure that the number of operations that can be handled is recorded, and to include a mechanism by which this number of operations cannot be exceeded. This would be a very valuable input to the ACA model, and consideration should be given to its introduction.
- Switches which have met the manufacturers fault closure ratings should be immediately tagged as “Non Fault Closure Switches” – and this too should also be included within the model. Perhaps this should be used to drive the reliability factor?
- The rules and methodology surrounding data point combination appears to be transparent and logical.
- The model contains some locational information; however, it is unclear what this is, or what can be determined from the information presented. (raw data, columns G&H). It appears that only Environment (Raw Data – Column AB) is used within the health score derivation. Consideration should be given to the identification and use of more granular data.
- There is no real information to drive the duty factor module. If the number of operations cannot be easily established, then THESL may want to consider either network position or switch function e.g. Normally open point or nodal switching point?

Model Calibration

- Average Life is set in accordance with Kinetics report at 30 years. Considering the current ages range of the asset portfolio presented, this figure looks acceptable, however should be kept under review.
- HI1 is purely driven by asset age. Consider sourcing and using more granular input data.
- Condition point calibration appears to suit an average life type asset condition model. i.e. some values will improve asset health score, some will reflect enhanced degradation.
- Evidence of relative weighting consideration between attributes within condition calibration tables. This is positive. Assigned calibration values are within the range expected for this methodology.
Model Outputs

- Mapping between health score and health index appears to be correct.
- THESL have not confirmed their belief or understanding that it represents an accurate reflection of their asset base.
- The ageing mechanism calculation appears to be working as expected.
- From a functional point of view, this more appears to be working correctly.

Specific areas of concern.

1) Consideration should be given to the inclusion of the number of fault operations in relation to the manufacturers rating as described above.

2) THESL have yet to confirm that Health score/Index profiles produced by this model are considered to be an accurate reflection of the actual asset base, and that future year projections would be considered reasonable given the engineering and asset management expertise within the THESL organisation.

3) Enhancement of locational input data will help provide a more granular insight in future years – However, the rate of asset replacement is considered achievable.
### Model Review #5 – KSO Oil Circuit Breaker ACA Model

**Review Location:** EA Technology HQ, Capenhurst, UK.  
**Review Date:** 06-Dec-2017  
**Reviewer:** Andrew Harrison

**Files provided by THESL for consideration:**
- KSO OIL CB ACA Model considerations.docx
- KSO_OIL_RCM_CERTIFIED_WORKSHEET_V3.xlsx
- MODEL FORMULATION_KSO_Oil_CB_V1.xlsx
- MODEL OUTPUT_KSOOILCB_V1.xlsx
- KSO Breaker_OC_RCM_V2_Certifi.docx

**Data Inputs**

- The input data shown in the model formulation document aligns with the RCM maintenance study undertaken within THESL, and the condition points are considered appropriate for this asset class.
- The rules and methodology surrounding data point combination appears to be transparent, logical. However, concerns have been identified in relation to the calibration of condition points, and the application of health score collars – See below.
- The model contains some locational information; however, it is unclear what this is, or what can be determined from the information presented. (raw data, column I)
- Circuit breaker environment and location Factor condition is uniform across the asset portfolio – This is unusual.
- The raw data table may contain a number of operations counter field (Column x – “Counteraf”). This would be a suitable indicator which could be used to drive a duty factor. Other alternative possibilities may include circuit breaker function (line, Tx, Cap Bank, Bus tie etc.) or the presence of auto reclose facility. Currently the duty factor is defaulted to 1.
- Condition information appears to be patchy in places, but reasonably well populated overall.

**Model Calibration**

- Average Life is set in accordance with Kinetrics report at 45 years. This may be considered a little pessimistic, however, 45 years would be regarded as acceptable given the intention to retire all assets within this population in the next few years.
- HI1 is purely driven by asset age.
- CNAIM models which are based around an average working life should contain calibration values which are less than 1.0 for assets which are identified as being in a good condition. There is no evidence of this within the material presented for review.
- Evidence of relative weighting consideration between attributes within condition calibration tables.
- Evidence of partially repaired deficiencies carrying a greater calibration weighting over confirmed deficiencies. See below.
Model Outputs

- Mapping between health score and health index appears to be correct.
- The ageing mechanism calculation appears to be working as expected.
- The health score profiles are consistent with those expected for a portfolio of assets which is being managed off the system.
- With a current population of 40 assets within this group, which are due to be retired, consideration should be given to the amount of effort that should be put into the further development of this asset class model.

Specific areas of concern.

1) Partially repaired deficiencies calibration within this model have been set to carry a greater weighting over confirmed deficiencies (Yes – 104).

This appears to be an attempt to lower the health score of assets which have been identified as being in need of retirement that have already been included within a capital replacement plan. Applying a higher weighted calibration to assets identified as being "partially repaired, however in need of follow up", so as to inflate their asset health scores such that they become a higher priority than assets already programmed for retirement is not valid grounds for health score manipulation within this methodology.

A more appropriate solution may be to add an additional identifier field into the equation, such that any assets which are due to be replaced under capital programmes are flagged and easily identified.

Should the calibration supplied as part of this review be applied to assets within this model, then THESL run the risk of masking assets in very poor condition with assets for which a partial intervention may suffice.

2) Locational Information
The model appears to have locational information which has been transferred from a data field labelled “Suburb”. Other documentation leads the reviewer to imply that this information is intended to be used for project prioritisation rather than having a material influence upon expected asset condition which can be captured within the asset health score.

There is no issue with including additional information fields within the model to aid asset identification or specific prioritisations – however, such information should not be incorporated into the health score derivation!

3) Calibration philosophy
CNAIM models which are based around an average working life should contain calibration values which are less than 1.0 for assets which are identified as being in a good condition. The calibration presented here is more suited to a maximum life based model.

4) Partial discharge survey
Consider the introduction and inclusion of partial discharge surveying to the condition assessment of this asset class.
Model Review #4 – 4kV Oil Circuit Breaker ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 06-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration:
- 4kV OIL CB_ACA MODEL_OUTPUT_V2.xlsx
- MODEL FORMULATION.xlsx (no date or version control evident)
- 4kV OIL CB (THESL_REPLY).docx

Data Inputs

- The model formulation document provides a breakdown of all observed and measured condition points from a variety of old and new inspection forms.
- These inputs and data points are considered to be appropriate, with the new inspection form providing an improved inspection data set.
- No Partial discharge data input under measured condition?
- Rules and methodology for data point combination appears to be transparent, logical and reasonable. Application of caps and collars appears to be acceptable.
- No evidence of the influences considered in relation to circuit breaker location, situation or operating environment other than “Indoor”.
- No evidence of Circuit breaker duty contained within the model. Operations count, circuit breaker function and or features such as auto-reclose would be considered appropriate inputs.
- Condition information appears sketchy.

Model Calibration

- Reliance on Kinetics report to set average life is not defendable. 128 of a circuit breaker population of 192 exceed the average normal expected life.
- HI1 is purely driven by asset age.
- Asset condition information appears sketchy as the current health score is the same as HI1 in the majority of cases.
- The range of calibration values chosen by THESL are more suited to a maximum life investment model rather than an average life investment model. All values are greater or equal to 1.0.
- Evidence of relative weighting consideration between attributes within condition calibration tables. Attempts appear to be in line with discussions during model development.
- Evidence of partially repaired deficiencies carrying a greater calibration weighting over confirmed deficiencies. This must be addressed via calibration review.
Model Outputs

- Mapping between health score and health index appears to be correct.
- The ageing mechanism calculation appears to be working as expected.
- The outputs from this model are not considered to be credible at this point.
- It appears that there is insufficient asset condition data to drive the model correctly, which when combined with poor average life calibration, and missing duty and locational information produce results which are considered unrepresentative of the true asset portfolio condition.

Specific areas of concern.

1) Partially repaired deficiencies calibration within this model have been set to carry a greater weighting over confirmed deficiencies (Yes – 104).

This appears to be an attempt to lower the health score of assets which have been identified as being in need of retirement that have already been included within a capital replacement plan. Applying a higher weighted calibration to assets identified as being "partially repaired, however in need of follow up", so as to inflate their asset health scores such that they become a higher priority than assets already programmed for retirement is not valid grounds for health score manipulation within this methodology.

A more appropriate solution may be to add an additional identifier field into the equation, such that any assets which are due to be replaced under capital programmes are flagged and easily identified.

Should the calibration supplied as part of this review be applied to assets within this model, then THESL run the risk of masking assets in very poor condition with assets for which a partial intervention may suffice.

2) Calibration philosophy
CNAIM models which are based around an average working life should contain calibration values which are less than 1.0 for assets which are identified as being in a good condition. The calibration presented here is more suited to a maximum life based model.

3) Partial discharge survey
Consider the introduction and inclusion of partial discharge surveying to the condition assessment of this asset class.
Model Review #3 – 3Ph Overhead Ganged Switches ACA Model

Review Location: EA Technology HQ, Capenhurst, UK.
Review Date: 05-Dec-2017
Reviewer: Andrew Harrison

Files provided by THESL for consideration (all received via email 4th Dec 2017):

- SWOHGANG_ACA Model_V2.xlsx
- Model Formulation_SWOHGANG_V2.xlsx
- SWOHGANG (THESL_REPLY).docx

Model Inputs

- The model uses the same list of inputs as the previous model review, which appear to be appropriate, and where condition points are mapped/combined this has been done in line with the spirit of CNAIM.
- It is unclear why the model now contains assets which do not belong to THESL.
- THESL should confirm whether these assets need to be within the model, and if deemed unnecessary, they should be removed. In the event that they are required, these assets should be clearly identified as NOT THESL PROPERTY, and they should be treated as a separate sub group of the asset class – and calibrated accordingly. It is inadvisable to include assets which are not subject to the same rules, practices and protocols as all other THESL assets, (e.g. maintenance schedules) within the same asset sub group category.
- Year of manufacturer data has been sourced from alternative data sources. The original source data is not visible, and therefore cannot be reviewed.

Model Calibration

- Asset Average age has been stated as being set in accordance with Kinetics technical report.
- 31 of 973 assets are older than this technical asset life, therefore this appears to be reasonable.
- THESL have not identified any Locational variation – this represents an area for improvement.
- THESL have not identified any Situational variation, as all assets are situated outdoors – this is reasonable.
- THESL have not identified any ranges in operational duty – this represents an area for improvement.
- Condition Calibration – Factors and collars for low score condition points are considered higher than would normally be expected. However this appears to reflect THESL practices and policies discussed during the course of the project. [ e.g. Condition Score 1 => Factor 1.3, and collar of 4].
Model Outputs

- Evidence of ageing rate re-calculation, and applications of ARRF
- Health Index and Health score profiles appear to be correctly calculated/presented
- The ageing mechanism calculation appears to be working as expected.
- The model results appear to reflect the discussions and opinions expressed by THESL during the course of the model development project.
Model Review #2 – Station Power Transformers ACA Model

Review Location: EA Technology, Capenhurst, UK
Review Date: 12th December 2017
Reviewer: Tracy Pears

Files provided by THESL for consideration (Emailed on 4th December 2017):

- Station Power Transformers Model Output (Updated).xlsx

Data Inputs

- The model includes two observed condition inputs: external condition of tank (corrosion) and oil leaks. The inspection form responses that have been used to derive the two condition inputs are considered to be appropriate.
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- The original version of the model output included partial discharge and temperature readings (although all of the PD readings were zero) but the information was not incorporated into the model. No measured condition information has been included in the updated version of the model. As the model incorporates DGA, oil and FFA data, the inclusion of measured condition information is not regarded as essential at the present time, particularly if THESL have doubts over the accuracy of the temperature readings.
- THESL stated in the email accompanying the revised model output that ‘the Location Factor has been implemented to take into account where the assets are situated’. This is not evident in the revised model output and the Location Factor is set to unity for all assets.
- Transformer duty has been included in the model based on the maximum percentage utilisation of the asset under normal operating conditions. This is a useful addition to the model as it introduces more granularity to the expected lives of the asset population.
- The duty and condition fields within the model are well populated.

Model Calibration

- The expected service life has been set at 44 years for all asset types; this has been reduced from 45 years in the original version of the model output. As the average age of the station power transformer population is over 40 years and more than 50 percent of the assets are over 44 years old, this figure seems to be too low. It is suggested that the service life is increased for different subsets of the population; this could be as straightforward as setting the service life depending on the date of manufacture (e.g. pre- or post-1980 as in the CNAIM transformer models).
- The calibration values have been set separately for external condition and oil leaks depending on the location of the deficiency. The factors and corresponding collars for oil leaks from the base of the tank have been set to have the most significance and this seems to be a reasonable approach. The condition collars have been set to align with THESL’s intervention / replacement activities and are considered to be appropriate.

---

1 Station Power Transformers Model Output.xlsx (provided by THESL on 17 October 2017)
The oil test results from the station power transformers have been categorised into one of three categories based on the acceptable limits for dielectric breakdown strength, moisture content and acidity specified in C57.106-2015 – IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment. The classifications that THESL have used and the calibration settings for the Oil Test Modifier appear to be reasonable.

Following the initial review, THESL have reduced the condition state calibration values such that the lowest score is 0 and the highest score is 10 for hydrogen, methane, ethane and ethylene and 8 for acetylene.

- Reducing the lowest condition state score from 2 to 0 has significantly reduced the number of assets where the Current Health Score is ‘forced’ by the DGA Test Collar. This seems to be a reasonable reflection of the DGA test results in the model.
- The DGA divider value should be set to give a DGA Test Collar of 7 or greater if there is an indication of a potential end-of-life fault. As the highest condition state scores for all of the gases have been reduced, THESL should review the DGA divider value / highest condition state scores to ensure that the DGA Test Collar values are 7 or greater in cases where the gas levels are indicative of end-of-life.

**Model Outputs**

- Since the initial review, the model has been extended to include the estimation of future health score and health index. The future health scores estimated by the model align with the application of the ageing mechanism (forecast ageing rate and ageing reduction factor) as applied in CNAIM.
- The current health index profile shows more than 50 percent of the assets in the HI 4-5 and 5-6 bands. This broadly corresponds to the number of assets that are older than the expected service life of 44 years and is unlikely to be providing an accurate reflection of the asset health or the remaining useful lives of the station power transformers.
- The future year health score predictions are unlikely to be an accurate as the expected lives of a large proportion of the population are too low and hence the forecast ageing rate is too high.

**Specific areas of concern**
Model Review #1 – Submersible Transformers ACA Model

Review Location: EA Technology, Capenhurst, UK
Review Date: 7th December 2017
Reviewer: Tracy Pears

Files provided by THESL for consideration (Emailed on 4th December 2017):
- Submersible Transformers Model Output (Updated).xlsx

Data Inputs

- The model includes three observed condition inputs, with corrosion and oil leak deficiencies having been split into separate inputs following the Stage 1 review. The inspection form responses used to derive the three condition inputs are considered to be appropriate.
- The approach to mapping and combining the data inputs is transparent, logical and reasonable.
- The measured condition inputs have been removed from the updated version of the model. The measured condition modifier only influences the health score of a small number of assets (less than 2 percent of the population in the original version of the model output but, provided that the readings are believed to be accurate, it is recommended that all available information is included in the model.
- No environmental influences have been included in the model; i.e. the Location Factor is set to unity for all assets. It was suggested during the detailed model review in Stage 1 that 'sites prone to flooding' could be incorporated as a component of the Location Factor to allow more differentiation between assets.
- Transformer duty has been included in the revised model based on the maximum percentage utilisation of the asset under normal operating conditions. This is a useful addition to the model as it introduces more granularity to the expected lives of the asset population.
- The duty and condition fields within the model are well populated.

Model Calibration

- The expected service life has been set at 33 years for all asset types; this has been reduced from 35 years in the original version of the model output. The average age of the submersible transformer population is around 15 years and less than 10 percent of the assets are over 33 years old; hence, the expected service life used in the model is probably reasonable. However, it is understood that there are significant differences between manufacturers/models and/or periods of manufacture; the inclusion of this additional knowledge would add more granularity to the results and better inform asset intervention/replacement programmes.
- The calibration values have been set separately for external condition and oil leaks depending on the location of the deficiency. The factors and corresponding collars for oil leaks from the base of the tank have been set to have the most significance and this seems to be a reasonable approach. The condition collars have been set to align with THESL's intervention / replacement activities and are considered to be appropriate.

1 Submersible Transformers Model Output_V1.xlsx (provided by THESL on 21 July 2017)
**Model Outputs**

- Since the initial review, the model has been extended to include the estimation of future health score and health index. The future ageing mechanism (forecast ageing rate and ageing reduction factor) has been implemented in line with the Common Methodology and the future health scores estimated by the model align with the values obtained from the CNAIM HV Transformer (GM) model.
- The future year health score predictions indicate that 349 assets will have reached end-of-life (health score ≥8) in 5 years' time. This appears to be in-line with the submersible transformer replacement activity currently undertaken by THESL.

**Specific areas of concern**
REPORT

A Review of Toronto Hydro's Newly Developed Asset Health Models

Prepared for: Toronto Hydro-Electric System Ltd

Project No: 116410
Document Version: 2.0 Final
Date: 17 November 2017

www.eatechnology.com
Version History

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<td>A. Harrison, Tracy Pears &amp; Linda Hull</td>
<td>Draft for review by THESL</td>
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<td>17 November 2017</td>
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<td>A. Harrison, Tracy Pears &amp; Linda Hull</td>
<td>Updated to incorporate feedback from THESL; Addition of appendices II, III and IV with high level review of additional 3 models</td>
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Final Approval

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Professional Engineers
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Name: Andrew William Harrison
Number: 100517465-01
Limitations: Review of Toronto Hydro Electric Systems
Limited Asset Condition Assessment methodology at that plant in Toronto, Ontario.
Collaborator: Michael Tap, P.Eng.
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Association of Professional Engineers of Ontario

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Contents

1. Introduction ................................................................................................................................. 1
2. Scope and Objectives .................................................................................................................... 2
   2.1 Scope of Project ....................................................................................................................... 2
   2.2 Objective of Project ................................................................................................................. 2
   2.3 Approach ............................................................................................................................... 3
3. The Common Methodology ........................................................................................................... 4
4. Review of THESL's Asset Health Models .................................................................................... 7
   4.1 Submersible Transformer Model .............................................................................................. 7
   4.2 Overhead 3-Phase Gang Operated Switch Model ................................................................... 12
   4.3 Summary ............................................................................................................................... 17
5. Approach to Asset Criticality ....................................................................................................... 19
   5.1 Asset Criticality in CNAIM .................................................................................................... 19
   5.2 THESL's Approach to Asset Criticality .................................................................................. 19
   5.3 Summary ............................................................................................................................... 20
6. Approach to Model Calibration .................................................................................................. 21
   6.1 The Purpose of Model Calibration ......................................................................................... 21
   6.2 THESL's Approach to Model Calibration ............................................................................. 22
   6.3 Derivation of Future Health Index Profile ............................................................................. 23
   6.4 Use of Alternative HI Banding .............................................................................................. 24
   6.5 Summary ............................................................................................................................... 24
7. Approach to Validation of Model Outputs ................................................................................. 26
8. Use of Asset Health Models within BAU .................................................................................... 27
   8.1 Use of CNAIM by GB DNOs .................................................................................................. 27
   8.2 Use of CNAIM by THESL ..................................................................................................... 28
   8.3 Summary ............................................................................................................................... 28
9. Discussion .................................................................................................................................... 29
   9.1 Essential Elements of Strategic Investment Planning ............................................................ 29
   9.2 THESL Implementation .......................................................................................................... 32
10. Conclusions and Recommendations ........................................................................................ 36

Appendices

Appendix I Definitions
Appendix II Station Power Transformer Model
Appendix III 4kV Oil Circuit Breakers
Appendix IV Wood Poles
1. Introduction

Toronto Hydro Electric System Limited (THESL), a wholly owned subsidiary of Toronto Hydro Corporation, owns and operates the electricity system that delivers electricity to approximately 761,000 customers located in Toronto. It is the largest municipal electricity company in Canada, and distributes around 19% of the electricity consumed in the province of Ontario.

THESL’s distribution network comprises over 13,000km of underground cables and 15,000km of overhead lines which delivered 25,373GWh of electrical energy around the state of Ontario in 2016. THESL has been recognised by the Canadian Electricity Association as a sustainable electricity company in recognition of the THESL’s commitment to providing electricity to customers in a way that minimises financial and environmental risks while maximising the benefit to society.

As part of its on-going commitment to progress towards excellence in sustainability, THESL is focussed on continuously improving its Asset Management practices. As part of this commitment, THESL has commenced the implementation of asset health models based on the Common Network Asset Indices Methodology (CNAIM). The Common Methodology, as it is often referred to, is the approach used by Distribution Network Operators (DNOs) in Great Britain to report asset health and criticality as part of their regulatory reporting requirements. THESL's intention is to use the outputs from their CNAIM-based models to support an advanced condition-based approach for planning and evaluating strategic capital investments and day to day maintenance activities.

EA Technology has supported the GB Distribution Network Operators through the development of the Common Network Asset Indices Methodology. Following the successful approval of CNAIM, we have worked with each of the DNOs to implement the methodology and embed it within their organisations.

Whilst the structure of the Common Methodology is publicly available, there is very limited experience of applying the Common Methodology outside Great Britain. In recognition of this, THESL have commissioned EA Technology to review their progress made to date, and to provide assistance as the methodology is rolled out to all assets.

This report presents the findings of our review into the progress made to date by THESL. The report is structured as follows:

- Section 2 presents the scope, objectives and approach to the project.
- Section 3 provides a brief overview of the Common Methodology.
- Section 4 provides a review of the structure of the models, the data used and the implementation of the CNAIM methodology.
- Section 5 summarises THESL’s approach to quantifying asset criticality.
- Sections 6, 7 and 8 summarise THESL’s approach to calibration of the models, how the outputs have been validated and now the models will be used within business-as-usual.
- Section 9 discusses the observations from THESL’s implementation of CNAIM.
- Section 10 summarises the conclusions and recommendations from the Stage 1 of the project.

Abbreviations and acronyms used in the report are listed and defined in Appendix I.
2. **Scope and Objectives**

2.1 **Scope of Project**

THESL have expressed a desire to enhance their in-house asset management capability by implementing a new asset health model to replace their existing Asset Condition Assessment (ACA) methodology. This is driven by a desire to put in place an asset health methodology that reflects the actual condition of the electrical network and can be used to inform the development of a condition based strategic investment programme and day to day maintenance activities.

THESL have appointed EA Technology to review the progress made in developing their new asset condition assessment tool. The project encompasses:

- reviewing the current processes and practices being employed by THESL to assess the extent to which they align with the principles and philosophy of CNAIM;
- where appropriate, to provide specific recommendations if it is considered that improvements can be made; and
- provision of on-going support to THESL's implementation team as the new CNAIM-based methodology is rolled out across the asset population.

In order to review the progress made by THESL, it has been agreed that EA Technology will review the following two asset class models in detail to assess the extent to which THESL's approach aligns with CNAIM:

- Submersible Transformers; and
- Overhead 3-Phase Gang Operated Switches (Manual).

2.2 **Objective of Project**

The overall project comprises four stages as highlighted below:

- **Stage 1** – Review the two newly developed asset health models in detail and provide a more high-level review of the data inputs and calibration values for a further three models*

- **Stage 2** – Common Methodology and asset condition modelling training

- **Stage 3** – On-going support during modelling programme roll-out

- **Stage 4** – Assistance with regulatory submission

This report presents our findings for Stage 1 of the project, which comprises the following tasks:

1. review the newly developed asset health models, and associated documentation;
2. review the approach to quantification for determination of asset criticality;
3. review THESL's approach to model calibration;
4. review the approach to validation of model outputs;
5. determine how the asset health models will be used within business-as-usual (BAU);
6. identify any areas for improvement and make recommendations; and
7. document the findings from tasks 1-6 in a report.

* Following the completion of the detailed model reviews, it was agreed that a high-level review of the substation power transformer, 4kV oil circuit breaker and wood pole models would be undertaken (see Appendices II, III and IV).
2.3 Approach

When the project was commissioned, it was intended to carry out Stage 1 through a combination of off-site and on-site working, including a series of workshops covering tasks 1 to 5 (see Section 2.2 above) during a single visit to THESL’s offices. However, issues with the process for visa and licence applications for business purposes within the province of Ontario have resulted in an unforeseen delay in EA Technology personnel being granted the appropriate permissions to work in Canada. Therefore, the review has been undertaken from the UK using the following documents provided by THESL:

- Submersible Transformers Operating Context.pdf
- Submersible Transformers Model Output_V1.xlsx
- Inspection form – Submersible Transformers.xlsx
- Overhead Gang Operated Switches Operating Context.pdf
- Overhead Gang Operated Switches Model Output_V1.xlsx
- Inspection Form – 3 Phase Overhead Gang Operated Switches.xlsx

The content of these documents and THESL’s approach to tasks 1 to 5 have been explored via a series of teleconference and Webex meetings held on the following dates:

- Tuesday 18 July 2017
- Thursday 27 July 2017
- Thursday 3 August 2017
- Tuesday 8 August 2017
- Thursday 10 August 2017

In addition, a teleconference/Webex meeting was held on Friday 11 August 2017 to outline the findings from the Stage 1 review and to discuss the recommendations and suggested training requirements for Stage 2.
3. The Common Methodology

Within Great Britain, Distribution Network Operators are regulated by Ofgem, a government appointed regulator. Ofgem use an economic approach to regulation by agreeing a suite of performance based targets and operating licence contractual terms with DNOs over a series of “Price Control Periods”. These targets range from metrics which reflect customer experience, overall network performance through to capital and revenue allowances.

The GB energy regulator Ofgem introduced regulatory reporting requirements for GB Distribution Network Operators for the regulatory period running from 2015 to 2023 (referred to as RIIO-ED1). RIIO (Revenue = Incentives + Innovation + Outputs) marks a significant shift away from the previous RPI-X regulatory approach aiming to reduce costs within the utility sector to a more outcome-based regulatory reward system.

In order to facilitate these changes, a number of modifications to the requirements placed on network operators via their operating licences have been introduced. These include the requirement for DNOs to jointly develop a common framework referred to as the Common Network Asset Indices Methodology (CNAIM or the Common Methodology), such that DNOs adopt a common approach to the evaluation of asset health and criticality. DNOs are now required to report information on asset health and criticality using this Common Methodology. This enables Ofgem to be able to make direct comparisons between each of the GB licence holders.

The Common Network Asset Indices Methodology covers 25 electrical assets classes including Switchgear, Transformers, Overhead lines and Cables.

Most of the GB DNOs already had Condition Based Risk Management (CBRM) decision support tools developed in conjunction with EA Technology. Thus, CBRM was the logical starting point for the network operators’ working group in developing a new common reporting standard and EA Technology was invited to assist in the development of the DNO Common Network Asset Indices Methodology (CNAIM). An overview of the process that has been developed is shown in Figure 1.

The Health Score provides a measure of the condition of an asset and the proximity to the end of its useful life. This includes the current health which is informed by observed and measured

---

*DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017:  https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf*
condition factors as well as the future health based on assumptions on the likely future deterioration. The methodology includes age based elements and provides a continuous scale for the assessment of asset health. The methodology also specifies the exact relationship between the Health Score of an asset and its probability of failure.

In addition, the methodology includes a common approach for the evaluation of the likely consequences of failure associated with condition based failures, expressed in monetised values. The criticality of each asset is then determined by comparing the consequences of failure for that asset with the average for the population.

The information is used for the regulatory reporting of the following three components:

- Health Index which relates to asset health and probability of failure;
- Criticality Index which relates to the consequences of failure; and
- Risk Index which is a monetised risk measure determined from the combination of the Health Index and Criticality Index.

Only the first element of CNAIM (i.e. the derivation of a Health Index) is considered here.

Under the Common Methodology, the current health of an asset is represented by a Health Score (the Current Health Score) using a continuous scale between 0.5 and 10, where 0.5 represents an asset in the same condition as would be expected when new. A Health Score of 5.5 represents the point in an asset's life beyond which significant deterioration may begin to be observed. This is where the probability of failure of the asset is approximately double that of a new asset. A Health Score of 10 represents an asset in extremely poor condition, where the probability of failure is 10 times that of a new asset.

The detail of the CNAIM health index formulation is depicted in Figure 2 and can be summarised as follows:

1. **An Initial Health Score** is calculated using knowledge and experience of the asset's performance and expected lifetime, taking account of factors such as manufacturer, operational experience and operating conditions (duty, proximity to coast, etc.).

2. **The Initial Health Score** is then adjusted by the Health Index Modifier, which is based on the known condition of the asset. It includes condition that is gathered by inspecting the asset, together with any condition information obtained through diagnostic tests, measurements or functional checks. The observed and measured condition inputs are used to derive a Health Score Factor, Health Score Cap and a Health Score Collar.
(3) A Reliability Modifier can also be applied to modify the Current Health Score to reflect generic issues affecting asset health and/or reliability associated with a specific manufacturer or model type. The Reliability Modifier comprises a Reliability Factor and a Reliability Collar.

(4) The Current Health Score is then derived by adjusting the Initial Health Score by the Health Score Factor and the Reliability Factor, subject to upper and lower thresholds defined by the Health Score Collar, the Reliability Collar and the Health Score Cap.

(5) For the purposes of regulatory reporting, the Current Health Score is mapped onto one of five Health Index (HI) bands using the criteria in Table 1.

### Table 1 Health Index Banding Criteria

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<td>HI5</td>
<td>≥8</td>
<td>≤15</td>
</tr>
</tbody>
</table>
4. Review of THESL's Asset Health Models

THESL are developing their asset health models using Alteryx and have provided EA Technology with the model inputs and outputs in separate Excel spreadsheets for submersible transformers and overhead 3-phase gang operated switches respectively. In order to check the algorithms and calculation sequencing, the input data has been loaded into EA Technology's CNAIM spreadsheet models that were developed as part of the implementation of the Common Network Asset Indices Methodology with the GB DNOs. The Current Health Index results as provided by THESL have then been compared with those calculated using the EA Technology CNAIM models.

A general observation on the model outputs provided by THESL is that there is no means of identifying individual assets other than the unique equipment number. It is suggested that some additional information fields (such as site/location, manufacturer/model/type) are included in the models to enable assets to be more easily identified. Inclusion of additional information fields will be particularly useful during calibration sessions as it will allow more detailed interrogation/filtering of the model outputs.

Observations on the implementation of the CNAIM methodology, including the data inputs used, the calibration settings and the calculated health indices are provided for submersible transformers and overhead 3-phase gang operated switches in Sections 4.1 and 4.2 below.

4.1 Submersible Transformer Model

Submersible transformers are distribution transformers used to step down the primary voltage of the distribution system to the voltage supplied to the end customer. They are termed submersible as they are normally situated within underground vaults hidden beneath sidewalks or boulevards. Submersible vaults tend to be confined spaces which are exposed to ingress of dirt and debris and, in addition, are subject to flooding often due to drainage issues.

The model output provided by THESL includes 6,213 assets. This compares with a population of approximately 8,600 submersible transformers across the Toronto Hydro service territory. It is recommended that THESL include the entire asset population within the model, irrespective of how little data currently exists. CNAIM models are designed to work with incomplete data sets and a health score can be derived for any asset provided a manufacturing or commissioning date is available. Where a definitive date is not available, EA Technology can offer guidance on ways to estimate an indicative date; for example, certain model/types may have been manufactured or purchased over a known time period.

The review of THESL's submersible transformer model is based on the CNAIM HV Transformer (GM) model and follows the steps depicted in Figure 2.

4.1.1 Initial Health Score

The first step in determining the Current Health Index of an asset is to derive its Initial Health Score. This is based on the age of the asset, the normal expected service life of assets in that asset class, asset location and an approximate indication of asset duty or work load.

Expected Service Life

The THESL model uses an expected service life of 35 years which is based on Kinectrics Report K-418021_RA-0001-R002 on the useful life of assets.

In a population of over 6,000 submersible transformers, it would not be unreasonable for there to be variations in expected service lives for different subsets of the population. The differences could

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\[ \text{Submersible Transformers Model Output_V1.xlsx (provided by THESL on 21 July 2017)} \]

\[ \text{Reliability Centered Maintenance Analysis Operating Context: Submersible Transformer, 18 March 2016, Toronto Hydro Electric System Limited} \]
be a result of manufacturer/model types, asset design or operating voltage. If Toronto Hydro is aware of variations in service lives for subsets of assets, and these can be identified easily, then the inclusion of this additional knowledge would add more granularity to the results and better inform asset intervention / replacement programmes.

**Location Factor**

In the CNAIM models, the Location Factor is derived from three components:

1. distance from coast;
2. altitude; and
3. corrosion rating (as a measure of proximity to industrial pollution).

THESL have included these inputs in their submersible transformer model but, at present, the Location Factor has been set to 1 (i.e. a default value has been applied) as the company does not have sufficient data to determine distance to coast, altitude and corrosion category.

It should be noted that the components of the Location Factor in the CNAIM models have been set by GB DNOs to align with the environmental influences that affect asset lives in Great Britain. These may not be relevant in Ontario and, indeed, there could be additional environmental influences that affect the service lives of submersible transformers. Discussions with THESL have indicated that some sites are prone to flooding; this could be incorporated as a component of the Location Factor, possibly in place of corrosion rating.

**Duty Factor**

In the CNAIM transformer models, the Duty Factor for each asset is derived from its maximum percentage utilisation under normal operating conditions. THESL have applied the same calibration settings in their submersible transformer model as those in the CNAIM HV Transformer (GM) model. However, Toronto Hydro have stated that their submersible transformers are typically run at 75% under normal operating conditions and, hence, the Duty Factor has been set to unity.

Consideration could be given to including additional ways of differentiating between the loading of different transformers; for example, by taking account of the type of load (residential, commercial, industrial) supplied by each transformer. However, it is suggested that this refinement is only included in the future if there is insufficient granularity in the results to make informed investment decisions with the data already in the model.

**4.1.2 Health Score Modifier**

In the CNAIM models, a Health Score Modifier is created for each asset based on the available condition information relating to the asset. It is based on observed condition, measured condition and any specific test results applicable to the asset class.

The observed and measured condition inputs that have been included in THESL's submersible transformer model are discussed in the sections below. The resulting observed and measured condition factors have been combined using the Maximum and Multiple Increment (MMI) technique using the same calibration settings as in the CNAIM HV Transformer (GM) model.

**Observed Condition Modifier**

The CNAIM HV Transformer (GM) model has a single observed condition input of transformer external condition. THESL have made good use of their available condition data and included 'connections condition' as a second observed condition input in their submersible transformer model.

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1. Table 32: Duty Factor Lookup Table – Distribution Transformer, DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017
2. See Section 6.7.2 in DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017
Table 2 lists the responses to the questions on THESL's inspection forms that have been used to derive the two observed condition inputs. The responses have been converted to scores and the scores combined to produce the External Condition of Tank Factor and Connections Condition Factor as explained in two documents provided by Toronto Hydro. The approach to mapping and combining the data inputs as described is transparent and logical and would be regarded as defensible if challenged.

<table>
<thead>
<tr>
<th>Condition Input</th>
<th>Inspection Question Used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External Condition of Tank</strong></td>
<td>Corrosion Deficiency</td>
</tr>
<tr>
<td></td>
<td>Corrosion Level</td>
</tr>
<tr>
<td></td>
<td>Active Oil Leak</td>
</tr>
<tr>
<td></td>
<td>Oil Gauge Level Low</td>
</tr>
<tr>
<td></td>
<td>Oil Leak Present</td>
</tr>
<tr>
<td></td>
<td>Volume of Oil Leak</td>
</tr>
<tr>
<td><strong>Connections Condition</strong></td>
<td>Bushing Deficiency</td>
</tr>
<tr>
<td></td>
<td>Ground Issue Identified</td>
</tr>
<tr>
<td></td>
<td>Secondary Connections Deficiencies</td>
</tr>
</tbody>
</table>

It is not strictly necessary to combine multiple inspection inputs into a single condition modifier; for example, corrosion issues and oil leakage issues could be treated as two observed condition inputs. This may ease the burden of the data mapping / combination element of THESL's rollout of the remaining asset health models.

**External Condition of Tank**

The External Condition of Tank modifier is derived from inspection information relating to corrosion and oil leaks as shown in Table 2.

THESL have explained that there is currently no data validation built into the inspection forms and hence it is possible for an inspector to select no corrosion deficiency / no oil leak present and then select a corrosion level / volume of oil leak of low, medium or high. Where such data discrepancies exist, THESL have used the corrosion level / volume of oil leak scores assuming that a corrosion deficiency / oil leak exists. This is a reasonable approach to adopt until the data discrepancies have been resolved.

The calibration settings for the External Condition of Tank Factor and the corresponding caps and collars in THESL's model and the CNAIM HV Transformer (GM) model are shown in Table 3.

<table>
<thead>
<tr>
<th>Condition Criteria</th>
<th>THESL Calibration Settings</th>
<th>CNAIM Calibration Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor</td>
<td>Cap</td>
</tr>
<tr>
<td>As New</td>
<td>0.9</td>
<td>10</td>
</tr>
<tr>
<td>Good</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Slight Deterioration</td>
<td>1.1</td>
<td>10</td>
</tr>
<tr>
<td>Poor</td>
<td>1.4</td>
<td>10</td>
</tr>
<tr>
<td>Very Poor</td>
<td>1.8</td>
<td>10</td>
</tr>
<tr>
<td>Default</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

THESL have applied stronger factors to the 'poor' and 'very poor' condition criteria and significantly more aggressive collars to the 'slight deterioration' and 'poor' condition criteria; this has the effect of forcing the Current Health Score of an asset with an external tank showing slight deterioration (e.g. minor surface corrosion) or an external tank in poor condition (e.g. significant corrosion) to a

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1. Toronto Hydro Health Index Model v1.docx (provided by THESL on 21 July 2017)
2. Submersible Transformers Model Output_V1.xlsx (provided by THESL on 21 July 2017)
minimum value of 4 or 5.5 respectively. The factor values may have been set too high and should be assessed as part of a full calibration review (see Section 6).

In the discussions that have taken place during this review, THESL have explained that the condition collars have been set to align with the outputs / intervention triggers from their maintenance programme. This means that the results from the model will provide a view of the corrective maintenance and short-term replacement activity that is required rather than providing a strategic view of the asset portfolio. This is discussed further in Sections 6 and 9.

Connections Condition

Table 4 shows the calibration settings that THESL have applied to the Connections Condition Factor and the corresponding caps and collars. There is no equivalent condition input in the CNAIM HV Transformer (GM) model.

Table 4 Calibration Settings for Connections Condition

<table>
<thead>
<tr>
<th>Condition Criteria</th>
<th>Factor</th>
<th>Cap</th>
<th>Collar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Wear</td>
<td>1</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Some Deterioration</td>
<td>1.2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Substantial Deterioration</td>
<td>1.4</td>
<td>10</td>
<td>5.5</td>
</tr>
<tr>
<td>Default</td>
<td>1</td>
<td>10</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The Connections Condition Factor values have been set to be lower than the External Condition of Tank values to reflect THESL’s intervention / replacement strategy that the external tank condition is more significant than the condition of the transformer connections.

Again, the connections condition collars have been set to align with maintenance activities, and where an asset has some level of deterioration, this will give a pessimistic representation of its position on the HI scale (i.e. where an asset is situated within its lifecycle) in an implementation based on the philosophy and principles of CNAIM.

In THESL's submersible transformer model, the Observed Condition Factor is derived using the MMI technique using the same settings as in the CNAIM HV Transformer (GM) model¹ and only considers a single factor. As THESL have included two observed condition inputs (i.e. external tank condition and connections condition), then consideration could be given to increasing the number of factors to two. This could be explored as part of a full calibration review of the Observed Condition Modifier.

Measured Condition Modifier

The CNAIM HV Transformer (GM) model has three measured condition inputs: oil acidity, partial discharge and temperature readings. THESL have included partial discharge and temperature readings in their submersible transformer model.

The responses to the questions on THESL’s inspection forms that have been used to derive the two measured condition inputs are shown in Table 5; the response to 'transformer oil temp' is only used where 'transformer oil temp max' is not available.

Table 5 Measured Condition Inputs in the Submersible Transformer Model

<table>
<thead>
<tr>
<th>Condition Input</th>
<th>Inspection Question Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Discharge</td>
<td>Partial Discharge (dB)</td>
</tr>
<tr>
<td></td>
<td>Partial Discharge Detected</td>
</tr>
<tr>
<td>Temperature Reading</td>
<td>Transformer Oil Temp (degree C)</td>
</tr>
<tr>
<td></td>
<td>Transformer Oil Temp Max (degree C)</td>
</tr>
</tbody>
</table>

¹ Table 13: Observed Condition Modifier – MMI Calculation Parameters, DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017
The calibration settings for the Partial Discharge Factor and the corresponding caps and collars in THESL’s model and the CNAIM HV Transformer (GM) model are shown in Table 6. THESL have applied stronger factors to the 'low' and 'medium' dB values and a more aggressive collar to the 'medium' dB value. These settings appear to be reasonable given that the PD definition criteria are different in the two models (THESL are using dB readings whereas CNAIM uses dB reading as a percentage of the manufacturer's recommendation).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>THESL Calibration Settings</th>
<th>CNAIM Calibration Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>No PD</td>
<td>1  10  0.5</td>
<td>-</td>
</tr>
<tr>
<td>Low (&lt;20dB)</td>
<td>1.1 10  0.5</td>
<td>Low 1 10  0.5</td>
</tr>
<tr>
<td>Medium (20-40 dB)</td>
<td>1.3 10  5.5</td>
<td>Medium 1.1 10  0.5</td>
</tr>
<tr>
<td>High (&gt;40dB)</td>
<td>1.5 10  8</td>
<td>High (not confirmed) 1.3 10  5.5</td>
</tr>
<tr>
<td>Default</td>
<td>1  10  0.5</td>
<td>High (confirmed) 1.5 10  8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default 1 10  0.5</td>
</tr>
</tbody>
</table>

The calibration settings for the Temperature Reading Factor and the corresponding caps and collars in THESL’s model and the CNAIM HV Transformer (GM) model are shown in Table 7. It should be noted that although THESL have stated in the documentation provided that a collar of 5.5 and 6.5 has been applied to 'moderately high' and 'very high' temperature readings respectively, the output from the model indicates that a collar of 0.5† has been applied to all temperature readings‡.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>THESL Calibration Settings</th>
<th>CNAIM Calibration Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (≤40°C)</td>
<td>1  10  0.5</td>
<td>Normal 1 10  0.5</td>
</tr>
<tr>
<td>Moderately high (40°C-110°C)</td>
<td>1.2 10  5.5</td>
<td>Moderately high 1.2 10  0.5</td>
</tr>
<tr>
<td>Very high (≥110°C)</td>
<td>1.4 10  6.5</td>
<td>Very high 1.4 10  5.5</td>
</tr>
<tr>
<td>Default</td>
<td>1  10  0.5</td>
<td>Default 1 10  0.5</td>
</tr>
</tbody>
</table>

In THESL’s submersible transformer model, the Measured Condition Factor is derived using the MMI technique using the same settings as in the CNAIM HV Transformer (GM) model§; i.e., using both condition factors included in the model. It should be noted that the MMI technique does not appear to be working correctly where the Temperature Readings Factor is >1 and the Partial Discharge Factor is equal to 1. As an example, where the Temperature Readings Factor=1.2 and the Partial Discharge Factor=1, the model returns a Measured Condition Factor of 1.33 rather than 1.2**.

4.1.3 Reliability Modifier

In the CNAIM models, the Reliability Modifier can be applied to reflect any reliability issues affecting an asset or family of assets that cannot be appropriately reflected by the Location and Duty Factors (i.e. factors that affect the expected life) or detected in the condition assessment.

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† Table 14: Measured Condition Input – Temperature Reading, Toronto Hydro Health Index Model v1.docx (provided by THESL on 21 July 2017)
‡ Raw Data tab (Column BW) on Submersible Transformers Model Output_V1.xlsx (provided by THESL on 21 July 2017)
§ Following the delivery of draft v1.0 of this report it is understood that this discrepancy has been resolved.
** Table 15: Measured Condition Modifier – MMI Calculation Parameters, DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017

It is understood that this calculation has been corrected following delivery of draft v1.0 of this report.
THESL have not included the Reliability Modifier in their submersible transformer model. If any issues affecting particular groups of assets become apparent in the future, then the Reliability Modifier would be an appropriate place to capture and utilise this knowledge. However, it must be noted that the reliability input values directly impact the asset health score and, as such, their use must be justifiable.

4.1.4 Current Health Score

In CNAIM models, the Current Health Score of an individual asset is determined from its Initial Health Score adjusted by the Health Score Factor and Reliability Factor, subject to the upper and lower thresholds defined by the Health Score Cap, Health Score Collar and Reliability Collar. The Current Health Score is a measure of the remaining useful life of an asset and is the value used to derive its current performance (i.e. its probability of failure).

The Current Health Score in THESL’s submersible transformer model has been derived in the same way as described in the Common Network Asset Indices Methodology document. However, the way in which condition collars have been applied means that it is unlikely that the Current Health Score derived in THESL’s model is a reflection of the remaining useful life of the submersible transformer population. This is discussed further in Section 6.

4.1.5 Current Health Index Profile

For the purposes of regulatory reporting in Great Britain, the Current Health Score calculated in the CNAIM models is mapped onto one of five Health Index bands (using the criteria in Table 1). THESL have used the same bandings in the submersible transformer model and the resulting health index profile with the calibration settings as described in Sections 4.1.1 to 4.1.3 is shown in Figure 3.

![Figure 3: Current Health Index Profile for Submersible Transformers (THESL Calibrations)](image)

As stated in Section 4.1.4, the way in which condition collars have been applied means that it is unlikely that the health index profile depicted in Figure 3 is a true reflection of the asset health (and therefore remnant life) of the submersible transformer population. This is discussed further in Section 6.

4.2 Overhead 3-Phase Gang Operated Switch Model

Overhead 3-phase gang operated switches, also known as load interrupter switches (LIS) or Air-break switches (ABSW), are pole mounted, manually operated devices that are used to sectionalise and
isolate overhead line circuits. LIS can be either horizontally or vertically mounted and, when operated, all 3 phases are simultaneously either opened or closed.

The model output* provided by THESL includes 334 assets. This compares with a population of approximately 1,300 3-phase gang operated switches in Toronto Hydro's distribution system territory†. EA Technology recommends that THESL include the entire asset population within the model, irrespective of how little data currently exists. This will provide visibility of where additional asset information should be collected in order to gain a better understanding of the current health of the entire population of 3-phase gang operated switches. It is understood that that manufacturing/commissioning date information is not available for a significant number of assets; it may be possible to use an indicative date based on, for example, manufacture/purchase dates of certain model/types, pole installation dates, line construction dates, etc.

The review of THESL's overhead 3-phase gang operated switch model is based on the CNAIM HV Switchgear (GM) - Distribution model and follows the steps depicted in Figure 2.

4.2.1 Initial Health Score

The first step in determining the Current Health Index of an asset is to derive its Initial Health Score. This is based on the age of the asset, the normal expected service life of assets in that asset class, asset location and an approximate indication of asset duty or work load.

Expected Service Life

The THESL model uses an expected service life of 45 years based on internal guidelines for the normal expected life of overhead gang operated switches. It should be noted that this differs from the value of 50 years in the Kinectrics Report K-418021_RA-0001-R002 on the useful life of assets§§§.

Consideration could be given to splitting the expected service life by, for example, manufacturer / model type, asset design or operating voltage. If THESL are aware of variations in service lives for subsets of assets, and these can be readily identified, then the inclusion of this additional knowledge would add more granularity to the results and better inform asset intervention / replacement programmes.

Location Factor

As stated in Section 4.1.1, the Location Factor in the CNAIM models is derived from three components: distance from coast, altitude and corrosion rating (as a measure of proximity to industrial pollution). These inputs have been selected by GB DNOs to align with the environmental influences that affect asset lives in Great Britain.

THESL have included these inputs in their overhead gang operated switch model but, at present, the Location Factor has been set to 1 (i.e. a default value has been applied) as the company does not have sufficient data to determine distance to coast, altitude and corrosion category. These factors may not be relevant in Ontario and THESL may wish to consider whether there are other environmental influences that affect the service lives of overhead gang operated switches that could be included in the model.

Duty Factor

In the CNAIM HV Switchgear (GM) - Distribution model, the Duty Factor is set to unity. THESL have adopted the same approach.

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* Overhead Gang Operated Switches Model Output_V1.xlsx (provided by THESL on 21 July 2017)
† Reliability Centered Maintenance Analysis Operating Context: Overhead 3-Phase Gang Operated Switches (Manual), 21 April 2016, Toronto Hydro Electric System Limited
4.2.2 Health Score Modifier

In the CNAIM models, a Health Score Modifier is created for each asset based on the available condition information relating to the asset. It is based on observed condition, measured condition and any specific test results applicable to the asset class.

The observed and measured condition inputs that have been included in THESL's overhead gang operated switch model are discussed in the sections below.

Observed Condition Modifier

The CNAIM HV Switchgear (GM) - Distribution model incorporates five observed condition inputs as follows:

1. Switchgear external condition;
2. Oil leaks / gas pressure;
3. Thermographic assessment;
4. Switchgear internal operation and condition; and
5. Indoor environment.

These differ from the condition inputs used by THESL and, instead, the company has made use of available and relevant information to this asset group. The responses to the condition-related questions on the inspection form for overhead gang operated switches that have been used to derive the four observed condition inputs are shown in Table 8. THESL have made good use of their available inspection data and the mapping of the data inputs to the measured condition factors is logical and transparent.

Table 8  Observed Condition Inputs in the Overhead Gang Operated Switch Model

<table>
<thead>
<tr>
<th>Condition Input</th>
<th>Inspection Question Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Interruption</td>
<td>Arc interrupter</td>
</tr>
<tr>
<td></td>
<td>Interphase operator link</td>
</tr>
<tr>
<td></td>
<td>Operating handle deficiency</td>
</tr>
<tr>
<td>Switch Condition</td>
<td>Insulator deficiency</td>
</tr>
<tr>
<td></td>
<td>Stationary contact deficiency</td>
</tr>
<tr>
<td></td>
<td>Switch blade deficiency</td>
</tr>
<tr>
<td></td>
<td>Switch base deficiency</td>
</tr>
<tr>
<td>Connection Condition</td>
<td>Connection deficiency</td>
</tr>
<tr>
<td></td>
<td>Ground connection deficiency</td>
</tr>
<tr>
<td>Corrosion Deficiency</td>
<td>Corrosion deficiency</td>
</tr>
<tr>
<td></td>
<td>Corrosion level</td>
</tr>
</tbody>
</table>

The Circuit Interruption Factor, Switch Condition Factor and Connection Condition Factor have been determined from the maximum score assigned to the associated inspection questions. The Corrosion Deficiency modifier is derived from inspection information relating to whether corrosion is present and, if so, the level of the corrosion deficiency.

The calibration settings for the observed condition factors and the corresponding caps and collars in THESL's model and the CNAIM HV Switchgear (GM) - Distribution model are shown in Table 9. It should be noted that the calibration settings and descriptions differ between the model output spreadsheet and the model description documents that have been provided; the values in Table 9 correspond to those in Overhead Gang Operated Switches Model Output_V1.xlsx.

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*Tables 16, 17 and 18 in Toronto Hydro Health Index Model v1.docx (provided by THESL on 21 July 2017)*
### Table 9  Calibration Settings for Observed Condition Factors, Caps and Collars

<table>
<thead>
<tr>
<th>Condition Criteria</th>
<th>Circuit Interruption Condition</th>
<th>Switch Condition</th>
<th>Connections Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal wear</td>
<td>Factor 1.1 Cap 10 Collar 4</td>
<td>Normal wear</td>
<td>Factor 1.2 Cap 10 Collar 4</td>
</tr>
<tr>
<td>Some deterioration</td>
<td>Factor 1.2 Cap 10 Collar 6.5</td>
<td>Some deterioration</td>
<td>Factor 1.4 Cap 10 Collar 6.5</td>
</tr>
<tr>
<td>Substantial deterioration</td>
<td>Factor 1.3 Cap 10 Collar 8</td>
<td>Substantial deterioration</td>
<td>Factor 1.8 Cap 10 Collar 8</td>
</tr>
<tr>
<td>Default</td>
<td>Factor 1 Cap 10 Collar 0.5</td>
<td>Default</td>
<td>Factor 1 Cap 10 Collar 0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition Criteria</th>
<th>Corrosion Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Factor 1 Cap 10 Collar 0.5</td>
</tr>
<tr>
<td>Normal wear</td>
<td>Factor 1.1 Cap 10 Collar 4</td>
</tr>
<tr>
<td>Low</td>
<td>Factor 1.2 Cap 10 Collar 5.5</td>
</tr>
<tr>
<td>Moderately high</td>
<td>Factor 1.3 Cap 10 Collar 6.5</td>
</tr>
<tr>
<td>Very high</td>
<td>Factor 1.4 Cap 10 Collar 8</td>
</tr>
<tr>
<td>Default</td>
<td>Factor 1 Cap 10 Collar 0.5</td>
</tr>
</tbody>
</table>

There are no equivalent condition inputs in the CNAIM HV Switchgear (GM) - Distribution model but the factor settings appear to have been set too high; for example, 'normal wear' would generally be expected to be set to 1 (as in the submersible transformer model). The weightings of 'some deterioration' and 'substantial deterioration' have been set to reflect the relative significance of the various deficiencies in terms of THESL's intervention / replacement activity. This approach is correct, but the values are probably too high and should be examined as part of a full calibration review.

As previously stated, THESL have set the condition collars to align with outputs / intervention triggers of their maintenance programme. This means that the results from the model will provide a view of the corrective maintenance and short-term replacement activity that is required rather than providing a strategic view of the asset portfolio. This is discussed further in Sections 6 and 9.

In THESL's overhead gang operated switch model, the Observed Condition Factor is derived using the MMI technique using the same settings as in the CNAIM HV Switchgear (GM) - Distribution model†. This is probably appropriate, but consideration could be given to changing the number of factors included (to either 2 or 4). This could be explored as part of a full calibration review of the Observed Condition Modifier.

### Measured Condition Modifier

The CNAIM HV Switchgear (GM) - Distribution model incorporates five measured condition inputs as follows:

1. partial discharge;
2. ductor test;
3. oil test;
4. temperature readings; and
5. trip test.

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*In the feedback provided on draft version 1.0 of this report, THESL have indicated that 'normal wear' should be 'repaired – no follow up'. It is understood that the labelling anomalies have been rectified.

† Table 13: Observed Condition Modifier – MMI Calculation Parameters, DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017
No measured condition values are collected as part of the inspection process and, hence, there are no measured condition inputs in THESL's overhead gang operated switch model. Measured condition information could be included at a later date if it becomes available, but its inclusion is not regarded as essential at the present time.

### 4.2.3 Reliability Modifier

In the CNAIM models, the Reliability Modifier can be applied to reflect any reliability issues affecting an asset or family of assets that cannot be appropriately reflected by the Location and Duty Factors (i.e. factors that affect the expected life) or detected in the condition assessment.

THESL have not included the Reliability Modifier in their overhead gang operated switch model. If any issues affecting particular groups of assets become apparent in the future, then the Reliability Modifier would be an appropriate place to capture and utilise this knowledge. However, it must be noted that the reliability input values directly impact the asset health score and, as such, their use must be justifiable.

### 4.2.4 Current Health Score

In CNAIM models, the Current Health Score of an individual asset is determined from its Initial Health Score adjusted by the Health Score Factor and Reliability Factor, subject to the upper and lower thresholds defined by the Health Score Cap, Health Score Collar and Reliability Collar. The Current Health Score is a measure of the remaining useful life of an asset and is the value used to derive its current performance (i.e. its probability of failure).

The Current Health Score in THESL's overhead gang operated switch model has been derived in the same way as described in the Common Network Asset Indices Methodology document. However, as the condition factor values appear to be too aggressive and the condition collars have been applied to align with maintenance activities, it is unlikely that the Current Health Score derived in THESL's model is a reflection of the remaining useful life of the population of overhead 3-phase gang operated switches.

### 4.2.5 Current Health Index Profile

For the purposes of regulatory reporting in Great Britain, the Current Health Score calculated in the CNAIM models is mapped onto one of five Health Index bands (using the criteria in Table 1). THESL have used the same bandings in the overhead 3-phase gang operated switch model and the resulting health index profile with the calibration settings as described in Sections 4.2.1 to 4.2.3 is shown in Figure 4.
As stated in Section 4.2.4, the way in which condition collars have been applied means that it is unlikely that the health index profile depicted in Figure 3 is a true reflection of the asset health (and therefore remnant life) of the population of overhead gang operated switches. This is discussed further in Section 6.

4.3 Summary

Toronto Hydro's implementation of CNAIM to derive a Current Health Score and an associated Health Index is in line with the approach outlined in the Common Network Asset Indices Methodology document. Good use has been made of the available inspection data to produce a number of observed and measured condition inputs for the two models. The mapping and combination of the data inputs is logical and transparent.

A general observation on the model outputs provided by THESL is that there is no means of identifying individual assets other than the unique equipment number. It is suggested that additional information fields are included in the models to enable assets to be more easily identified; examples include site/location of the asset and manufacturer/model/type. Inclusion of such information is particularly useful during calibration sessions as it will allow more detailed interrogation/filtering of the model outputs.

A few minor anomalies have been identified; these were highlighted in the sections above and are summarised below:

- The application of the MMI technique to calculate the Measured Condition Factor in the submersible transformer model does not appear to be working correctly where the Temperature Readings Factor is greater than 1.
- The values used for the Temperature Readings Collar in the submersible transformer model do not correspond to those stated in the Toronto Hydro Health Index Model description document provided by THESL.
- The values and descriptions used for the Circuit Interruption Modifier, Switch Condition Modifier and Connections Condition Modifier in the overhead gang operated switch model do not correspond to those stated in the Toronto Hydro Health Index Model description document provided by THESL.

THESL's models appear to contain a subset of the population of submersible transformers and overhead 3-phase gang operated switches'. It is recommended that THESL include the entire asset population within the models, irrespective of how little data currently exists. This will provide visibility of where additional asset information should be collected in order to gain a better understanding of the current health of the entire asset population. Where manufacturing/commissioning dates are not available, EA Technology can provide guidance on ways to estimate indicative dates such that a health score can be derived.

At present, the health index is derived purely from the condition inputs; i.e. the same average lives have been applied throughout each model and the Location Factor and Duty Factor are defaulted to unity. Going forwards, THESL may wish to consider enhancing the health index derivation as outlined in the sections above:

- The expected service life of assets could be split by, for example, manufacturer/model type, asset design or operating voltage.
- Environmental influences that are relevant in Ontario and affect the service life of assets could be incorporated into the Location Factor. One example highlighted during this review is to identify sites that are prone to flooding for inclusion in the submersible transformer model.

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1 Following the delivery of draft v1.0 of this report it is understood that THESL have addressed all of the minor anomalies.

† It is understood that the entire population for both asset classes have been included in their respective models.
• Inclusion of data to drive the Reliability Modifier. For example, the Reliability Modifier could be used to capture information on Suspension of Operational Practice / Operational Restrictions.

The inclusion of such refinements will increase the accuracy of the health index derivation and will allow more differentiation between assets. This is useful when determining the ageing rate of the assets, their performance (probability of failure), the level of risk associated with different assets and, ultimately, determining the optimum intervention programme based on risk.

Consideration could also be given to separating some of the condition inputs into additional modifiers; for example, in the submersible transformer model, corrosion issues and oil leakage issues could be treated as two observed condition modifiers rather than combining them to a single External Condition of Tank Modifier. This may ease the burden of the data mapping / combination element of THESL's rollout of the remaining models.

The key issue that has been identified during the review of the models is the way in which condition collars have been applied. This is likely to be distorting the results and, if the results are rolled forwards, will give a particularly pessimistic view of the future health index profile of the asset portfolio. This is discussed further in Section 6.
5. Approach to Asset Criticality

One of the key concepts within modern day asset management is that of 'asset criticality', and the recognition that not all assets within a large complex 'asset system' are of equal importance. This acknowledgement gives rise to the validity of using different management strategies for different natured assets which may or may not have similar technical or functional specifications. This principle is key when attempting to implement a transition to a risk based asset investment.

Within a risk based asset management framework, assets identified as being the most important are likely to be treated very differently to those with a lower order of criticality – and in some instances low criticality assets may be 'managed to fail'.

5.1 Asset Criticality in CNAIM

There are many different ways in which criticality can be established. Within CNAIM, criticality is determined purely by considering the consequences of asset failure in four different consequence categories; Network Performance, Safety, Financial and Environmental.

Once the average consequences of failure have been established for an 'average failure' for each of the assets within a CNAIM study, this average is then used to band the consequences of failure of all other assets within the portfolio. The bandings are in the form of a percentage of the portfolio’s calculated theoretical average consequences of failure as shown in Table 10.

<table>
<thead>
<tr>
<th>Criticality Index Band</th>
<th>Lower Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)</th>
<th>Upper Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>-</td>
<td>&lt; 75%</td>
</tr>
<tr>
<td>C2</td>
<td>≥ 75%</td>
<td>&lt; 125%</td>
</tr>
<tr>
<td>C3</td>
<td>≥ 125%</td>
<td>&lt; 200%</td>
</tr>
<tr>
<td>C4</td>
<td>≥ 200%</td>
<td>-</td>
</tr>
</tbody>
</table>

As this review project has progressed, THESL have painted a picture of an approach to asset investment in which all of the right investment drivers such as safety, performance, cost and criticality are being considered. However, at each stage, deliberations are often in isolation, and are being carried out in a predominantly manual and subjective manner. This fragmented approach has often been found to produce inconsistent results.

Experience has shown that when investment decisions are not made on a consistent basis, investment managers find it difficult to defend proposed investment projects when challenged. This is generally because the perceived benefits of undertaking projects are either not clear, quantified or directly comparable.

EA Technology have experienced this difficulty before, and have sometimes found investment managers then overstate project benefits in order to 'game the system' such that their proposals are realised. The situation can then be made worse in the event that the organisation as a whole is faced with constraints, as investment is unlikely to generate the best returns or risk mitigations at a time when it is most important to do so.

5.2 THESL's Approach to Asset Criticality

As THESL's project to develop a new tool for assessing asset health progresses, moves are being made to transition away from manual processes and time-based investment drivers. This is considered to be good practice. At the time of writing, THESL are developing a mechanism to
consider the 'cost of asset failure' in a more consistent and mechanised way - but at this stage only in (network performance) terms of 'customer impact'.

On an individual asset basis, customer impact is measured using a single financial metric which has two component parts:

1. The first relates to the fact that customer supplies have been interrupted and is assigned a monetary value of $30 CAD/kVA/event where the kVA rating used to make this financial determination is that of the asset affected by the incident or failure.

2. The second component aims to reflect the perceived willingness of customers to pay to avoid an outage. It has been derived from studies in Canada and North America and currently takes the form of a uniform rate of $15 CAD/kVA/hour for all customer types.

These values are understood to be under review. THESL may vary the values used within the new investment decision tool going forward if customer type data can be supplied on an asset by asset basis.

This approach is straightforward to implement, as the data required for implementation is minimal, and calculation simple to process. However, this approach falls down when considering assets which form part of the electrical system that have redundancy. As failures of assets within the such arrangements should have no noticeable impact upon the service received by customers, and therefore no quantifiable customer impact.

THESL have recognised this phenomenon and derive a 'customer impact risk' value which comprises of the financial kVA calculation described above with a probability of failure derived from their failure records and a judgement of the likelihood of asset failure causing damage or failure of adjacent operating plant so as to provide a quantifiable value which can be used for analytic purposes.

THESL are understood still to be in the early stages of developing this 'customer impact risk' valuation. When challenged during the discussion regarding this process, THESL accept that it would be currently possible for the results of critical assets to be lost within overall asset rankings. So, going forward, THESL intend to present the results from any customer impact assessments in asset class specific rankings.

Once works to establish the customer impact have been completed, THESL have indicated that criticality will be banded as per the Ofgem CNAIM document and used in the same way within the CNAIM methodology to produce a 5x4 matrix. However, it is not clear how this matrix is intended to be used within future BAU.

5.3 Summary

EA Technology recognise that THESL are still exploring the area of asset criticality and consequence quantification, and that the approach being taken by THESL may be subject to change. The approach being worked on at the time of writing is regarded as a reasonable first pass when quantifying the network performance aspects of asset failures, and it can be further developed as time progresses.

EA Technology would recommend that THESL look to extend the risk-based approach to consider all of the consequence categories included in CNAIM. This would enable THESL to compare the level of risk between asset classes on a consistent basis. Over the longer term, this would reinforce THESL's credentials as a sustainable electricity company.
6. Approach to Model Calibration

6.1 The Purpose of Model Calibration

The process of calibration of any risk based investment model is to ensure that the various model inputs and calculation components exert an appropriate influence upon the final results, i.e. neither too cautious nor too excessive. Model calibration needs to be approached in a disciplined and systematic way in order to ensure that the model outputs provide a robust and reliable indication of the health of the assets.

Through years of experience in this field, EA Technology has found that the best way to ensure that investment model results are deemed to be both meaningful and credible is to perform model calibrations through structured workshops. The workshops should involve the participation of a wide range of participants including asset experts, planners, maintenance engineers and asset managers to ensure their engineering knowledge and experience is reflected in the calibration process.

The calibration process starts by considering asset health, and only once the asset health outputs provide a meaningful and credible snapshot of the asset population, is it possible to move on to consider asset performance (in the form of probability of failure), consequences of failure, and then risk. As such, the majority of calibration effort is focussed on asset health. Otherwise, it is not possible to derive robust results for the probability of failure of an asset or asset related risk.

In order to calibrate the asset health results, the first step is to ensure understanding of the health score (or health index) scale. The numeric representation of the condition of each asset in the form of a health score is a means of combining information that relates to its age, environment and duty, as well as specific condition and performance information to give a comparable measure of condition for individual assets in terms of proximity to end of life and probability of failure. Current health scores are measured on a scale of 0.5 to 10, where 0.5 represents the best condition and 10 the worst. The concept is illustrated schematically in Figure 5.

![Figure 5 The Concept of Health Scores](image)

* When looking at future degradation, the health index is allowed to rise to a higher value to ensure that the effects of further degradation are captured in terms of the increase in PoF. The maximum future health index could be allowed to increase indefinitely. However, in practice, it has been found reasonable to limit it to a value of 15.
The health score represents the extent of degradation as follows:

- **Very low values of health score** (in the range 0.5 to 2.5) represent assets that are new or as new.
- **Low values of health score** (in the range 2.5 to 4.5) represent assets that are in good or serviceable condition. They show some observable or detectable deterioration at an early stage. In such a condition, the PoF remains very low and the condition and PoF would not be expected to change significantly for some time.
- **Medium values of health score** (in the range 4.5 to 6.0) represent the onset of significant deterioration*, although deterioration will still be in the early stages. The PoF of the assets is currently low, but it is set to rise in the coming years.
- **High values of health score** (in the range 6 to 8) represent measurable deterioration, with degradation processes starting to move from normal ageing to processes that potentially threaten failure. In this condition, the PoF is elevated and rising as further degradation progresses.
- **Very high values of health score** (>8) represent assets in unsatisfactory condition; i.e. advanced degradation processes have reached the point that they actually threaten failure. In this condition, the PoF is significantly raised and the rate of further degradation will be relatively rapid.

It is important to note that the ranges of health scores indicated above do not align with the HI bands within CNAIM and used by DNOs for regulatory reporting purposes. The ranges shown above are considered to show how the health score values relate to asset condition and proximity to end of life.

### 6.2 THESL's Approach to Model Calibration

THESL are in the process of developing a suite of asset investment models based on the Common Network Asset Indices Methodology. At the present time, these have been developed as far as the derivation of current asset health and they do not yet link to asset performance in terms of a probability of failure.

Given the current input data fed in to the new Asset Condition Assessment model, it would be fair to say that asset health is currently derived almost exclusively from collated asset condition information collected during routine inspection, and the results produced by the models are heavily influenced by the applied calibration, specifically, the use of condition point collars.

Whilst it is clear how THESL have calibrated the newly developed asset condition assessment models, the calibration process does not appear to follow the philosophy of calibration which would ordinarily be associated with CNAIM, as the outputs are directly linked to 'tactical' corrective maintenance rather than providing a more 'strategic' insight into the asset portfolio.

In the discussions that have taken place during this review, THESL have indicated that the relative weighting between different condition factors (e.g. External Condition of Tank Factor and Connections Factor in the submersible transformer model) have been set to reflect the significance of the various deficiencies. The 'weighting' approach taken to setting the condition factors is correct but should be reviewed to ensure that the values that have been applied are having the desired effect on the overall asset health score, and are not excessively weighted so as to distort the true health score profile of the asset base.

The Common Network Asset Indices Methodology is intended for strategic investment modelling purposes and assumes that the asset operator already has an established maintenance regime in place. Hence, condition collars should be used sparingly as they are only intended to be applied where existing routine maintenance activities and practices can no longer address asset deficiencies.

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* Onset of significant deterioration can be defined as the point at which asset condition cannot be maintained without additional intervention beyond routine maintenance activities.
identified during routine inspection. It is therefore recommended that THESL review the calibration of all of the condition collars.

THESL have explained that condition collars have been selected to directly align asset health scores with the results which they would use to categorise assets using their in-house corrective maintenance programme. This has the effect of ‘forcing’ assets into distinct health index bands which are then used to trigger specific tactical corrective actions. For example, a transformer which is observed during inspection to have a highly corroded tank will be forced into health index band HI5, thereby instructing an immediate asset replacement. Similarly, an overhead gang operated switch with moderately high levels of corrosion will be assigned to HI4 indicating that it is at the end of its serviceable life and will form part of the planned reactive replacement programme.

To illustrate the points raised above, the result of removing the condition collars in the overhead gang operated switch model can be seen in Figure 6. This is considered to be a more accurate representation of the asset health profile but needs further review as the condition factors appear to be too aggressive (see Section 4.2.2).

![Figure 6](https://example.com/figure6.png)

**Figure 6** Comparison of Current HI Profile for Overhead Gang Operated Switches

The average age of the population of overhead 3-phase gang operated switches is just over 19 years compared with an expected service life of 45 years. It can be seen from Figure 6 that the removal of the condition collars gives a better reflection of where the assets are likely to positioned within their lifecycle given that they are well maintained and comparatively young.

### 6.3 Derivation of Future Health Index Profile

THESL's application of condition collars will distort the ageing rate derivation required for the next stage of the CNAIM methodology such that future health score predictions could not be regarded as credible. This is illustrated in Figure 7 which shows the health index profile for overhead gang operated switches in five years' time with and without the condition collars applied. In the profile with the collars applied, the assets are moving quickly through the HI bands and approximately 50% of the assets are predicted to be in HI4 and HI5 after 5 years. The progression is much slower when the collars have been removed with very little movement compared with the current health index profile; this is to be expected given the age profile and underlying condition of the asset portfolio.
As previously stated, the HI banding scale used in CNAIM has been designed for regulatory reporting purposes whereby the health index and criticality index of an asset group is presented in the form of a 5 x 4 matrix. The CNAIM HI bands are not a particularly useful way of visualising the movement of assets through their lifecycle and THESL may wish to consider changing the health index banding to a more granular scale. An example is shown for the overhead 3-phase gang operated switches in Figure 8 where the assets have been grouped into bands 0-1, 1-2, etc.

In conclusion, the calibration settings that have been applied to the two models that have been reviewed as part of this project are not considered to be appropriate if THESL wish to adopt the
principles and philosophy of the Common Network Asset Indices Methodology. The model outputs, as they currently stand, are masked by a direct linkage to THESL’s maintenance programme. This is evident from the excessive use of condition collar calibrations that are preventing the outputs from providing a true 'strategic' insight for which the models are intended. This is discussed further in Section 9.
7. Approach to Validation of Model Outputs

Decision support tools such as THESL's ACA or CNAIM were initially conceived not to replace human decision making, but to assist with the task of making high volume investment decisions in a timely and consistent way. Far from replacing engineering experience and asset management expertise, investment models, when functioning correctly, should directly replicate an organisation's decision-making process, and would be expected to draw the same conclusions as experienced engineers and asset managers in the event that they were presented with the same information.

Within many walks of life, investment decision making can have very serious potential impacts upon budgets, system performance, and the rates customers and society would be expected to fund – and so it is important to get these often-large financial decisions right.

Along with the process of model calibration, the validation of the model outputs is essential to ensure that investment models produce credible results which directly align with the ethos, values and beliefs of the asset owner, system operator and regulatory authorities.

A company needs to be able to defend its position against both internal and external challenge (including regulatory push back) and, hence, validation should be undertaken at every stage of the decision-making process. This starts with the specification of data which must be collected from the field, right through to the final approvals process for investment project proposals.

Typically, CNAIM-type models are validated by a development and integration project team that is made up of a wide cross section of the business. This team will be supported by subject matter expertise which spreads throughout the entire business. These specialists would be expected to be engaged to review, improve and approve each of the individual processes that make up the larger investment decision making vehicle. Once the processes have been defined, documented and approvals completed, both the subject matter experts and the development team must then reach a consensus over any definitions, data requirements, model structures, reporting specifications or calibration settings which are required to determine the model outputs. All of these are then signed off by the development team project manager and senior asset manager within the organisation representing consensus that the outputs produced accurately reflect the true situation in the 'real world'.

Depending up on the organisation in question and the regulatory environment in which they operate, certain aspects of the process (e.g. the setting of calibration values) should be set or reviewed on a regular basis.

It is recognised that THESL are in the early stages of implementing improvements to their asset management practices and it would appear that the move from using asset condition assessment for planning tactical maintenance activities to longer term strategic planning purposes represents a significant shift in thinking. Hence, at present, THESL are unable to demonstrate a structured process for validation of the model outputs. EA Technology can assist with this as part of the proposed training activities.
8. Use of Asset Health Models within BAU

THESL is focussed on continuously improving its Asset Management practices. By implementing an asset health methodology based on CNAIM, THESL wishes to support an advanced condition-based approach for planning and evaluating capital investments and maintenance activities. THESL's progress with regards to implementing procedures for integrating the outputs from the asset health models into business as usual (BAU) practices has been explored via a series of web conferences.

Section 8.1 provides a brief overview of the use of CNAIM by GB DNOs, whilst Section 8.2 explores the progress made within THESL to use the outputs from its newly implemented CNAIM models. Our general observations based on our initial findings are summarised in Section 8.3.

8.1 Use of CNAIM by GB DNOs

The amount of revenue that network operators in Great Britain are permitted to collect from customers is determined via an incentive based regime referred to as RIIO (Revenue = Incentive + Innovation + Outputs). Under this form of regulation, rather than justifying the need for individual projects, network operators are assessed on the efficiency of their planned investments over the price control period, i.e. in terms of the outputs delivered to customers. In the case of expenditure on network replacement and refurbishment to manage assets nearing the end of their technical life, output is measured by considering the resultant impact on asset health and criticality.

As highlighted in Section 3, all distribution network operators in Great Britain are required to use CNAIM for reporting the underlying condition and criticality of their network assets. The outputs from CNAIM form the basis upon with the expenditure on ageing assets is evaluated (i.e. activities undertaken to manage condition based failures). This is assessed by consideration of the following HI/CI matrices, that are submitted to the regulator by the DNOs at the time of the price control review:

- the position at the start of the price control period;
- the forecast position at the end of the price control period (i.e. after 8 years) assuming no investment; and
- the forecast position at the end of the price control period following the proposed programme of investment.

CNAIM does not explicitly include a mechanism to enable the impact of different intervention strategies to be assessed. Rather, it requires that the impact be determined by consideration of the resultant change to the observed and/or measured condition and or asset criticality for the asset following intervention.

Once the Regulator approves the level of revenue, DNOs are required to report their actual movements in asset health and criticality on an annual basis in order to demonstrate the level of progress towards meeting their promised output. At the end of the regulatory price control period, the performance of the DNOs is assessed in terms of the level of output achieved. DNOs that over-deliver (i.e. the health / criticality of their assets is better than promised) are rewarded, whilst those that under-deliver are penalised. Importantly, the output is measured in terms of the movement in health and criticality compared to where assets are forecast to be at the end of the regulatory period, regardless of when the investment is made. Therefore, DNOs can smooth out their expenditure patterns over the full 8-year cycle even if this means intervening earlier than would be indicated by considering the current health and/or criticality in isolation.

* This can be asset replacement or asset refurbishment
8.2 Use of CNAIM by THESL

It is recognised that THESL is in the early stages of implementing improvements to its Asset Management practices, and arise still exploring how they intend to utilise the outputs from its CNAIM models to derive a finalised investment programme of works and to support maintenance.

To date, THESL’s implementation of CNAIM incorporates only the derivation of current asset health. Although, this is a good starting point for defining current investment needs, it is suggested that THESL consider extending their models to include future health. This is a relatively simple extension to the current models, requiring few additional computational steps. The use of current and future health profiles will provide a much more robust basis for determining future investment needs, and THESL will be in a strong position to move towards a risk based approach to investment planning over the medium term. However, the derivation of a reliable, and robust, forecast of the future health requires that the current health index provides an accurate reflection of the current condition of the assets and their proximity to end of life. More information on THESL’s calibration of the models is provided in Section 6.

At present, it is unclear how the models will be used to prioritise asset investment expenditure across different asset classes, and how the impact of different intervention strategies will be assessed, although the initial steps to assessing asset criticality represent a useful starting point.

It is understood that THESL currently envisage using the output of their CNAIM models to support both their day to day maintenance activities and longer term strategic planning. However, CNAIM is not designed to support day to day maintenance activities. Rather, CNAIM is designed for longer-term strategic planning of investment to manage the risk associated with condition based asset failures. The health score of an asset is a means of combining information that relates to its age, environment and duty, as well as specific condition and performance information to give a comparable measure of condition for individual assets in terms of proximity to end of life and probability of failure. The assessment of asset health assumes that essential maintenance activities have been, and will continue to be, carried out. Thus, whilst there is a direct link between CNAIM and maintenance, CNAIM is not designed to drive day to day maintenance activities.

8.3 Summary

CNAIM is the approach that all distribution network operators in Great Britain are required to use for reporting asset health and criticality. The GB regulator, Ofgem, uses the outputs to assess the efficiency of expenditure associated with condition based asset failures; i.e. the management of ageing assets.

THESL have indicated a desire to use CNAIM both for longer-term planning and evaluation of capital investments as well as the management of day to day maintenance activities.

In terms of capital investment planning, THESL’s implementation of CNAIM to date has focussed on the derivation of current asset health. This is a good starting point for defining current investment needs. However, it is suggested that THESL consider extending their models to include future health. This is a relatively simple extension to the current models, requiring relatively few additional computational steps.

The health score derived using CNAIM provides a measure of the remaining life of the asset based on its age, environment and duty and reflects that asset maintenance has been, and continues to be, undertaken. It is not intended to indicate when asset maintenance is required.
9. Discussion

The Common Methodology was created specifically for GB DNO regulatory reporting purposes as a result of changes to operating licence conditions stipulated by Ofgem for RIIO-ED1. The Common Methodology is based upon EA Technology’s Condition Based Risk Management methodology, which was specifically developed to support optimised investment to manage the risk associated with condition related failures. CBRM provides asset managers, engineers and maintenance planners with a holistic birds-eye 'strategic view' of the assets which make up their electrical distribution networks (i.e. where assets are situated within their lifecycle(s)), so as to provide an indication as to the likely remnant service life which could reasonably be expected from the asset before the risk of continued operation would be deemed to be unacceptable.

9.1 Essential Elements of Strategic Investment Planning

CBRM and CNAIM provide the basis for strategic investment modelling within mature asset management organisation, and support activities such as:

- exploring the effectiveness of the underlying asset maintenance;
- understanding the impact of proposed investment programmes; and
- identifying future investment requirements over the longer term, which can provide early sight of any significant investment 'walls', i.e. where a significant increase in investment is expected.

Sections 9.1.1 to 9.1.3 explore these activities in more detail.

9.1.1 Effectiveness of Underlying Maintenance Programmes

Strategic investment modelling methodologies such as CBRM or CNAIM work on the basis that the asset owner/operator already has an established maintenance regime in place. These methodologies are calibrated on the assumption that the maintenance will be effective enough to ensure that assets will realise their expected life based upon the asset's location, situation and duty.

Purely condition-based maintenance schemes, of which RCM is one of the best, are powerful processes in which asset owners and operators consider, in detail, the ways in which an asset could fail. The key to success often centres around the identification of specific parameters which could and should be measured/monitored in order to track the progress of any degradation. Subsequently, a programme of inspection and preventative maintenance, which is both technically and financially viable, can be determined. With large or complex assets, this can be extremely challenging.

Experience has shown, that when applied to electrical distribution assets, a number of common issues arise. These include not being able to identify all of the modes of failure, being unable to identify a parameter that can provide an indication of the level of deterioration within the asset or being able to determine a viable course of corrective action(s).

Even the best applications of purely condition-based maintenance approaches cannot maintain the condition of an asset portfolio to an acceptable (if not "perfect") standard indefinitely. Every asset can be considered to have a defined lifecycle, and must at some point be retired; the goal is to withdraw the asset from service before the risk of failure becomes unacceptable.

Our experience to date has found that organisations that do not keep track of condition based maintenance programmes (i.e. those organisations that do not have the facility/ability to take a longer term 'strategic view') have eventually reported spiralling reactive maintenance costs,
deteriorating system performance, and in the most serious of cases, a loss of overall system integrity caused by a maintenance approach that was unsustainable and created a 'wall' of investment need.

In contrast, professional asset managers who use the 'strategic view' provided by investment models such as CNAIM are able to track the rate at which assets progress through the defined health score scale. An assessment of the rate at which any asset degradation is taking place can be made, and therefore an inference of the effectiveness of the maintenance programmes can be determined.

This process promotes pro-active maintenance review and enables the effects of changes to existing practices to be quantified and assessed. This is much more effective, and will lead to more informed decision making than being solely reliant upon a reactive, condition-based management approach.

9.1.2 Effectiveness of Future Investment Programmes

One of the main outputs produced by CNAIM is a 5x4 matrix that displays the number of assets in each health index band against their corresponding criticality banding. Within the GB regulatory reporting framework, each DNO must produce a series of matrices for a range of scenarios as follows:

- the situation at the start of the price control period;
- the projected situation at the end of the price control period without any intervention; and
- the projected position at the end of the price control period following the proposed intervention.

The GB regulatory framework essentially considers the HI/CI designations within the 5x4 matrix as 'pigeon holes', each of which is assigned a number of risk points; i.e. the risk associated with an individual asset is not explicitly calculated. The total risk points (i.e. across the asset population) is used to quantify the level of risk.

By using a measure of risk that is the same for all assets, the benefit (i.e. the reduction in risk) for any intervention can be compared across asset classes. Thus, risk quantification provides the ability to rank all investment projects on the basis of cost/benefit in order to identify the optimum future investment plan.

The CNAIM-based models have the potential to enable the effect of different investment scenarios to be quantified in terms of the number of failures and overall risk. Scenarios that could be modelled include:

- maintaining the existing failure rate over a defined time period, (e.g. by replacing a fixed percentage/number of the asset population per year);
- maintaining the current level of risk over a defined time period;
- targeted intervention to replace/repair specific assets in selected years; and
- financially optimised replacement (optimising the cost of asset renewal with the reduction in overall risk).

An example of using CNAIM outputs in this way is highlighted in Table 11. It shows the quantification of total risk across a population of assets, together with a view of the likely number of failures. Risk and failure rates are provided for the current year and for a future year (year 5). In this example, if no intervention is undertaken (but existing maintenance activities are carried out), the total risk will increase by almost 40% as the number of failures increases from 39 to 53 failures. However, replacing 1% of the assets each year (prioritised in terms of their current health score) would result in a significant reduction in risk and condition related failures. Likewise, a targeted intervention programme to replace specific assets in selected years would result in a 20% reduction in risk compared with the current position.
### Table 11 Quantifying Risk under Different Investment Scenarios

<table>
<thead>
<tr>
<th>Intervention Programme</th>
<th>Total Risk</th>
<th>Number of Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 0 – current position</td>
<td>$4,233,068</td>
<td>39</td>
</tr>
<tr>
<td>Year 5 – no intervention</td>
<td>$5,852,458</td>
<td>53</td>
</tr>
<tr>
<td>Year 5 – 1% replacement per annum</td>
<td>$2,991,866</td>
<td>27</td>
</tr>
<tr>
<td>Year 5 – targeted intervention</td>
<td>$3,434,145</td>
<td>30</td>
</tr>
</tbody>
</table>

Using the outputs of CNAIM in this way, enables the effectiveness of future investment programmes to be evaluated and compared across different asset classes.

#### 9.1.3 Investment Walls

Stability and sustainability are two of the key attributes that any established asset management system should deliver. This is often challenging when large, complex asset systems have been designed, installed, and commissioned within a relatively short space of time - a scenario that is often found within the utility sector.

As time passes, and gradually asset deterioration starts to take hold, an increasing number of assets will be referred for asset replacement as the established routine maintenance programme struggles to maintain an adequate level of asset condition and/or performance. Due to the diverse nature of the assets contained within a large system such as a distribution network, and the variety of different makes and manufacturers of assets even within the same asset class, if left unmonitored, this can lead to a 'wall' (large numbers) of assets being referred for replacement within a very short time frame. Our experience in this area shows that businesses faced with this situation rarely have the capital, manpower, or operational ability to facilitate the required investment.

Because of their ability to estimate the likely condition and risk of the asset portfolio in future years, 'strategic' investment decision support tools such as CNAIM can be used to identify if and when investment walls are likely to appear in the future. This is illustrated in Figure 9 which shows the financially optimum replacement programme for an asset group over a 20-year period. It can be seen that an investment wall is predicted from year 6 and the level of replacement activity from year 6 to year 10 is likely to be more than five times greater than that over the first five-year period. The required level of investment begins to decrease from year 11 but remains high compared to the first five-year period.

![Figure 9 Financially Optimum Replacement Programme](image)

* The financially optimum replacement programme is determined by considering the investment cost versus risk on a present value basis for each asset in the asset group.
The ability to model the effects of different strategies means that investment modelling tools, such as CNAIM-based methodologies, can be used to develop sustainable strategic investment plans that effectively flatten the 'walls' and ensure that stability of both the asset base and asset management system are maintained.

9.2 THESL Implementation

THESL are looking to enhance their in-house asset management capability, and are looking to improve a number of processes and practices that are used to manage the asset base which forms their electrical distribution network. This includes:

- a replacement for its "Asset Condition Assessment" tool which is used to support investment decision making in relation to electrical plant and apparatus; and
- a desire to move away from a subjective predominantly manual existing time-based approach to routine maintenance to a more focussed, asset condition driven methodology.

The 'Asset Condition Assessment' tool in question is understood to have been developed by THESL in conjunction with Kinetics a number of years ago. Although it has been used within the business for a number of years, confidence in this condition assessment tool has wavered recently as THESL system planners and maintenance analysts no longer feel that the results produced by the system are representative of their electrical assets. THESL have also identified that the health score produced via the ACA tool cannot be used to provide an accurate reflection of the probability of failure of an asset.

The Common Network Asset Indices Methodology was identified as a more robust approach to deriving asset health and an objective route to determining asset criticality. A new project team, which sits within THESL’s engineering/asset management department has been established to implement new asset health models based on CNAIM. They have indicated that they intend to use the new asset health methodology to support their day to day maintenance activities as well as provide the basis for developing a long term strategic capital investment programme, as depicted in Figure 11.

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**Figure 10** THESL's Previous Situation

**Figure 11** THESL's Desired Project Outcome
The engineering function within THESL has expressed a desire to move away from an existing time-based approach to routine maintenance to a more focussed, asset condition driven methodology. To this end, THESL has conducted a maintenance review which comprised of an RCM study to determine asset specific maintenance activities and appropriate inspection frequencies. This revised inspection programme is understood to be embedded within the business and to be working effectively.

From the discussions which have taken place as part of this project, THESL has confirmed the existence of established data collection, data transfer and validation techniques which are applied to all information collected during routine on-site inspection/maintenance. Whilst detailed consideration of these practices is out-with the scope of this project, they appear to be reasonable and are broadly in line with the practices carried out by other organisations similar in nature to THESL. As such, they would be considered both compatible and acceptable for investment modelling purposes.

At the time of writing, the new CNAIM-based methodology project is still underway, and a number of new models have yet to be created. While good progress has been made in this area, THESL have encountered difficulty in being able to use the newly developed CNAIM based model to inform the strategic investment activities, as indicated by the red arrow in Figure 12.

Figure 12  Strategic Linkage

This appears to be down to the way in which the CNAIM model implementation has been carried out. The EA Technology review of two of THESL’s newly developed models has found that, from a mechanical point of view, the implementation is broadly in line with the CNAIM methodology as outlined within the Ofgem documentation. The calculation methodology is generally correct apart from a few minor discrepancies that have been highlighted in Section 4.

However, the way in which the models have been calibrated gives rise to a cause for concern. The EA Technology review has found that both of THESL’s newly developed models have been calibrated to align directly with the outputs derived from the maintenance study and inspection programme. This gives rise to an implementation approach as depicted in Figure 13. This is not in alignment with the objectives, philosophy and spirit of CNAIM; consequently, the asset condition outputs cannot provide a meaningful contribution to any strategic investment planning activity. The fundamental relationship between health score and PoF no longer exists and, thus, the calculated health scores cannot be related to probability of failure.

* It is understood that THESL have addressed the discrepancies following the delivery of draft v1.0 of this report.
The THESL model calibrations have been found to contain a significantly greater number of 'calibration collars' than would be expected to be found within a CBRM/CNAIM based model. The purpose of these collars is to force an asset's health score/index to a user defined minimum value. Within the CNAIM methodology, the use of condition collars should be used sparingly; they are only intended to be applied in circumstances where existing routine maintenance practices/activities can no longer address asset deficiencies identified during condition assessment. However, within the newly developed THESL models, rather than enabling the CNAIM methodology to form a "strategic" view of the asset portfolio, condition collars are being used to trigger "operational" activities - namely corrective maintenance. CNAIM was never intended to be used for this purpose.

In essence, THESL have the right tools. CNAIM and the RCM based maintenance schemes are complimentary, and will no doubt influence each other in the future. However, it is suggested that the activities are separated in line with the schematic presented in Figure 14 below.

The underlying process of RCM asset categorisation which triggers corrective maintenance activity, appears to be appropriate and to have been implemented correctly. However, it should be driven directly from the condition information collected from the field rather than the calculated results of a health index derivation*. In order to use the newly created asset health model to inform more strategic decision making, it is recommended that THESL revisits its approach to model calibration, particularly in terms of the use of condition collars. This would maximise the value of inspection data collected from the field, as once it has been checked and validated by existing data processing, the same input data could be used to drive both the 'tactical' corrective maintenance as well as more 'strategic' CNAIM based investment models.

* THESL's feedback on draft version 1.0 of this report indicates that although the calibration approach may suggest otherwise, THESL's intention was not to use the HI as a trigger for corrective maintenance.
Failure to review the calibration of the condition collars, as described above, will have the effect of masking the true position within the asset’s lifecycle, thereby preventing the CNAIM methodology from accurately representing the underlying condition of the asset portfolio. This will consequently distort the ageing rate derivation, such that any future asset health score estimations could no longer be regarded as credible.

So, in conclusion, THESL have the right tools in place to be able to migrate towards a risk based approach to future asset investment. However, the present implementation has become confused, and will only provide a ‘tactical’ view. The two activities (Maintenance and CNAIM) need to be separated such that it will be possible to create a ‘strategic’ investment view of the asset portfolio. This will enable future health score estimation, and then a determination of risk. From here THESL will be able to quantify the effects of specific investments in terms of the change in total risk associated with the asset portfolio. This will move THESL significantly closer to the ultimate aim of being able to relate $CAD investment directly to electrical system performance outcomes.
10. Conclusions and Recommendations

EA Technology believe that THESL have correctly identified the appropriate combination of tactical and strategic methodologies in order to develop their in-house asset management policies, practices and procedures. Although the scope of work upon which this review has been based is limited to consideration of the newly developed CNAIM-based models for determining a current health score, the project team has also considered some aspects of the RCM inspection regime where it has been deemed appropriate to do so.

EA Technology consider the combination of a CNAIM-style strategic investment model, supported by an effective RCM based inspection and corrective maintenance programme, as being good (if not best) practice for managing the asset base in question. When fully established, this combination will prove to be a very efficient and effective means of delivering a condition-driven, risk-based approach to asset investment.

Toronto Hydro’s implementation of CNAIM to derive a Current Health Score and an associated Health Index is in line with the approach outlined in the Common Network Asset Indices Methodology document. THESL have chosen the most appropriate model structures, and appear to have made the best use of the inspection data currently available to produce a number of observed and measured condition inputs for the two models; the mapping and combination of the data inputs is logical and transparent. It is recommended that additional information fields are included in the models as this will make calibrations sessions easier and allows more detailed interrogation of the model outputs. A few minor anomalies have been identified and it is suggested that these should be investigated and rectified as appropriate.

THESL’s models appear to contain a subset of the population of submersible transformers and overhead 3-phase gang operated switches. It is recommended that the entire asset population is included within the models, irrespective of how little data currently exists, as CNAIM-type models are designed to work with incomplete data sets. In addition, it will provide visibility of where additional asset information should be collected in order to gain a better understanding of the current health of the entire asset population. Where manufacturing / commissioning dates are not available, EA Technology can provide guidance on ways to estimate indicative dates such that a health score can be derived.

The key issue that has been identified during the review of the models is the way in which condition collars have been applied. It is believed that this is distorting the results and, if the results are rolled forwards, will give a particularly pessimistic view of the future health index profile of the asset portfolio. The application of model calibrations that are directly linked to the routine inspection and tactical maintenance programme does not follow the principles and philosophy of CNAIM.

Based on the findings of Stage 1 of the project, EA Technology recommends that the following activities are completed before THESL rolls out any further CNAIM-based models:

- Undertake training to gain a more detailed understanding of CNAIM in the following areas:
  - The background, underlying philosophy and principles of the core methodology for the estimation of current asset health.
  - Principles and process of calibration. It is suggested that this training session should include the calibration of one or both of THESL’s newly developed models that have been reviewed during Stage 1 of this project.
- THESL may wish to consider additional in-depth training to gain a better understanding of other elements of risk-based investment modelling; for example:

\[\text{It is understood that THESL have addressed the anomalies following the delivery of draft v1.0 of this report.}\]
\[\text{In THESL’s feedback on draft version 1.0 of this report, they have indicated that the entire population of both asset classes have now been included in the respective models.}\]
- determination and re-calculation of the asset ageing rate (used for estimating future asset health);
- inclusion of different failure modes and the determination of the constants in the probability of failure equation;
- approach to determining the consequences of failure in the four categories of network performance, safety, financial and environmental;
- derivation of asset criticality and criticality index;
- modelling different investment scenarios for risk-based decision making.

This training will assist THESL in the extension of their CNAIM-based models to incorporate future health, probability of failure and estimation of asset risk.

- Separation of the inspection result categorisation process from the newly developed models such that they align with the principles and philosophy of CNAIM.

EA Technology also recommends that the following activities are undertaken in conjunction with the roll-out of further models:

- Inclusion of future health score. This requires only a few additional computational steps and is useful when calibrating the models as a check to how fast the assets are moving through the health index bands. In addition, the use of current and future health profiles will provide a more robust basis for determining future investment needs.

- Presentation of the results on a more granular scale than that used in CNAIM (i.e. more health index bands). This will give better visualisation of the movement of assets through their respective lifecycles.

- Consideration could be given to including a larger number of condition modifiers; i.e. treating condition inputs separately rather than combining them as in the submersible transformer and overhead gang operated switch models. This may not affect the accuracy of the results but could ease the burden of the data mapping / combination element of THESL's planned rollout of the remaining models over a short time period.

EA Technology suggests the following longer-term recommendations to improve the CNAIM-based models:

- Refinements to increase the accuracy of the health score derivation. Examples could include:
  - splitting the expected service life of assets by manufacturer/model type, asset design or operating voltage;
  - incorporation of environmental influences that affect the service life of assets in Ontario into the Location Factor; and
  - inclusion of data on known reliability issues or operational restrictions to drive the Reliability Modifier.

The inclusion of such refinements will allow more differentiation between assets. This is useful when determining the ageing rate of the assets, their performance (probability of failure) and the level of risk associated with different assets.

- Further development in the area of asset criticality to consider all of the consequence categories included in CNAIM (i.e. network performance, safety, financial and environmental). This will enable THESL to compare the level of risk between asset classes on a consistent basis and, ultimately, to develop sustainable strategic investment plans.
## Appendix I  Definitions

This report may contain the following abbreviations which are commonly used when describing or discussing the subject matter related to this project.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ABSW</td>
<td>Air Break Switch – UK terminology for Overhead 3-phase gang operated switch</td>
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<tr>
<td>BAU</td>
<td>Business as Usual</td>
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<tr>
<td>CNAIM</td>
<td>Common Network Asset Indices Methodology</td>
</tr>
<tr>
<td>CoF</td>
<td>Consequences of Failure</td>
</tr>
<tr>
<td>CI</td>
<td>Criticality Index</td>
</tr>
<tr>
<td>CBRM</td>
<td>Condition Based Risk Management</td>
</tr>
<tr>
<td>DNO</td>
<td>Distribution Network Operator</td>
</tr>
<tr>
<td>EATL</td>
<td>EA Technology Ltd</td>
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<tr>
<td>GB</td>
<td>Great Britain</td>
</tr>
<tr>
<td>HI</td>
<td>Health Index</td>
</tr>
<tr>
<td>LIS</td>
<td>Load Interrupter Switch</td>
</tr>
<tr>
<td>Ofgem</td>
<td>The Office of Gas and Electricity Markets, the GB energy regulator</td>
</tr>
<tr>
<td>OHL</td>
<td>Overhead Line</td>
</tr>
<tr>
<td>MMI</td>
<td>Maximum and Multiple Increment</td>
</tr>
<tr>
<td>PoF</td>
<td>Probability of Failure</td>
</tr>
<tr>
<td>RCM</td>
<td>Reliability Centred Maintenance</td>
</tr>
<tr>
<td>RIIO / RIIO-ED1</td>
<td>The current regulatory price control period in Great Britain</td>
</tr>
<tr>
<td>RFP</td>
<td>Request for Proposal</td>
</tr>
<tr>
<td>RPI-X</td>
<td>Retail Price Index – a factor &quot;X&quot; (normally a %)</td>
</tr>
<tr>
<td>THESL</td>
<td>Toronto Hydro Electric System Ltd</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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</table>
Appendix II  Station Power Transformer Model

This Section provides a high-level review of THESL's station power transformer model based on the model output and accompanying Model Considerations document as provided by Toronto Hydro. The review is based on the CNAIM EHV and 132kV Transformer models. Observations are provided on the implementation of the CNAIM methodology, including the data inputs used, the calibration settings and the calculated health scores.

Initial Health Score

The Initial Health Score of an asset is based on the age of the asset, the normal expected service life of assets in that asset class, asset location and an approximate indication of asset duty or work load.

The following observations have been made about the inputs used in THESL's station power transformer model:

- **Expected service life.** The THESL model uses an expected service life of 45 years. This appears to be too low as more than 50 percent of the population of 246 assets are over 45 years old. It is suggested that the service life is increased for different subsets of the population. This could be as straightforward as setting the service life differently depending on the date of manufacture (e.g. pre- or post-1980 as in the CNAIM EHV and 132kV Transformer models) or setting the service lives by manufacturer/model, asset design or operating voltage.

- **Location Factor.** As already stated, the components of the Location Factor in the CNAIM models (distance from coast, altitude and corrosion rating) have been selected by GB DNOs to align with the environmental influences that affect asset lives in Great Britain. These factors may not be relevant in Ontario and THESL may wish to consider whether there are other environmental influences that affect the service lives of station power transformers that could be included in the model.

  Around 90% percent of the assets in the station power transformer model have been identified as being situated indoors with the remainder located outdoors. In the CNAIM models, an additional modifier is applied to the Location Factor to account for the shielding effect of the indoor environment. It is suggested that THESL may wish to consider the inclusion of an 'indoor modifier' to their station power transformer model.

- **Duty Factor.** In the CNAIM EHV and 132kV Transformer models, the Duty Factor for each asset is derived from its maximum percentage utilisation under normal operating conditions. THESL have set the Duty Factor to unity, presumably because the station power transformers are moderately loaded.

  Consideration could be given to including additional ways of differentiating between the loading of different transformers; for example, by taking account of the type of load (residential, commercial, industrial) supplied by each transformer. However, it is suggested that this refinement is only included in the future if there is insufficient granularity in the results to make informed investment decisions with the data already in the model.

Health Score Modifier

In the CNAIM EHV and 132kV Transformer models, a Health Score Modifier is created for each asset based on observed condition, measured condition, oil test results, DGA test results and FFA test results.

The condition and test inputs that have been included in THESL's station power transformer model and the derivation of the respective factors are discussed in the sections below. The resulting

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1. Station Power Transformers Model Output.xlsx (provided by THESL on 17 October 2017)
2. Station Power Transformer Model Considerations.docx (provided by THESL on 17 October 2017)
condition, oil, DGA and FFA factors have been combined using the Maximum and Multiple Increment technique using a maximum of 3 condition factors. This compares with using a maximum of 4 condition factors in the CNAIM EHV and 132kV Transformer models but appears to be reasonable given that THESL have not included a Measured Condition Factor in their station power transformer model.

**Observed Condition Modifier**

THESL have made use of their available condition data and have included ‘external condition of tank’ and ‘oil leaks’ as observed condition inputs in their station power transformer model. These differ from the observed condition inputs to the CNAIM EHV Transformer (GM) model; however, the inputs in THESL’s model are regarded as appropriate for this asset class. In addition, the approach to mapping and combining the data inputs is transparent and logical and would be regarded as defendable if challenged.

The observed condition calibration settings and the application of condition collars for poor and very poor oil leaks, and very poor external condition appear to be reasonable, with the weightings set to reflect the relative significance of the deficiencies in terms of THESL's intervention / replacement activity.

**Measured Condition Modifier**

The CNAIM EHV and 132kV Transformer models have two measured condition inputs: main transformer partial discharge and temperature readings. From the information provided, THESL appear to collect this data but have not included it in their station power transformer model. It is assumed that the information has not been used as THESL have doubts over the accuracy of the data collected. Measured condition information could be included at a later date, but its inclusion is not regarded as essential at the present time.

**Oil Test Modifier**

THESL have classified the oil test results from the station power transformers into one of three categories as follows:

- Class I: Mineral Oil is in satisfactory condition for continued use.
- Class II: Mineral Oil does not meet the dielectric breakdown voltage and/or water content requirement
- Class III: Mineral Oil is in poor condition and does not meet the limits.

The acceptable limits that have been applied for dielectric breakdown strength, moisture content and acidity have been taken from *C57.106-2015 – IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment*.

The classifications that THESL have used and the calibration settings for the Oil Test Modifier appear to be reasonable. However, it is noted that where the entries for moisture in oil, acid number and dielectric breakdown are all blank, but the oil test date is populated, then the asset is assigned an Oil Condition Score of Class II. This only applies to a single asset (equipment number 100000014996) but it would be more reasonable to apply neutral values where no data is provided; i.e. to assign an Oil Condition Score of Class I to the asset.

**DGA Test Modifier**

THESL have set the limits for the condition state scores for the five gases (hydrogen, methane, ethane, ethylene and acetylene) based on the four-level criterion specified in *C57.104-2008 – IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers*. With the exception of acetylene, the upper limits corresponding to excessive decomposition are lower than those used in Common Methodology. The same condition state multipliers as used in CNAIM have been applied

in the station power transformer model and, likewise, THESL have used the same DGA divider value as specified in Common Methodology to calculate the DGA Test Collar.

For all five gases, the lowest condition state score is 2 compared with 0 in the CNAIM calibration settings. This has the effect of increasing the DGA Score for low levels of gases compared with the CNAIM calibration values and, as a result, the calculated DGA Test Collar values are higher than those obtained using the CNAIM condition state calibration values. In THESL's station power transformer model, over 60 assets have a Current Health Score that has been 'forced' by the DGA Test Collar compared with only 3 assets when the CNAIM DGA condition state settings are applied. The 'Condition 1' criterion represents a condition state whereby the transformer is operating satisfactorily, and it is suggested that a condition state score of 0 would be more appropriate than a condition state score of 2.

The DGA Test Factor is derived by comparing the most recent DGA Score with the previous DGA Score. THESL have applied the same percentage change bands and calibration settings as used in CNAIM. However, it has been noted that where no previous DGA test results exist, a change category of 'Large' is applied, corresponding to a DGA Test Factor of 1.4. It is suggested that where there is only one set of DGA test results, then the change category should default to 'Neutral' (i.e. a DGA Test Factor of 1).

The derivation of the DGA Test Modifier in Common Methodology takes no account of the time period between tests. A possible enhancement to THESL's station power transformer model would be to set the change category and / or DGA Test Factor depending on the length of time between test results.

**FFA Test Modifier**

THESL have adopted the same approach as documented in the Common Methodology; i.e. using the same calibration values and equation for calculating the FFA Test Collar.

**Reliability Modifier**

THESL have not included the Reliability Modifier in their station power transformer model. If any issues affecting particular groups of assets become apparent in the future, then the Reliability Modifier would be an appropriate place to capture and utilise this knowledge. However, it must be noted that the reliability input values directly impact the asset health score and, as such, their use must be justifiable.

**Current Health Score**

In CNAIM models, the Current Health Score of an individual asset is determined from its Initial Health Score adjusted by the Health Score Factor, subject to the upper and lower thresholds defined by the Health Score Cap, Health Score Collar and Reliability Collar. The Current Health Score in THESL's station power transformer model has been derived in the same way.

The Current Health Score is a measure of the remaining useful life of an asset. As already stated, the expected service life appears to be too low given the age of the substation power transformer population in the model and, hence, the model is probably underestimating their remaining useful lives. In addition, the Current Health Score of around 25 percent of the assets have been 'forced' by the DGA Test Collar which is likely to be presenting an overly pessimistic view of the remnant lives of this subset of assets.
Appendix III 4kV Oil Circuit Breakers

This Appendix provides a high-level review of THESL's 4kV oil circuit breaker model based on the model output\(^*\) and accompanying Model Considerations document\(^†\) as provided by Toronto Hydro. The review is based on the CNAIM HV Switchgear (GM) models. Observations are provided on the implementation of the CNAIM methodology, including the data inputs used, the calibration settings and the calculated health scores.

Initial Health Score

The Initial Health Score of an asset is based on the age of the asset, the normal expected service life of assets in that asset class, asset location and an approximate indication of asset duty or work load.

The following observations have been made about the inputs used in THESL's 4kV oil circuit breaker model:

- **Expected service life**. The THESL model uses a maximum expected service life of 55 years. This appears to be too low as more than 80 percent of the population of 155 assets are over 55 years old. It is suggested that:
  - the model should be changed to use an average expected service life in order to maintain consistency with THESL's other asset health models; and
  - the service life should be increased for different subsets of the population. This could be as straightforward as setting the service life differently depending on the date of manufacture or setting the service lives by manufacturer/model or asset design.

- **Location Factor**. THESL have included the same components as in the CNAIM models (i.e. distance from coast, altitude and corrosion rating) but, at present, the Location Factor has been set to 1. THESL may wish to consider whether there are other, more relevant, environmental influences that affect the service lives of 4kV oil circuit breakers that could be included in the model.

- **Duty Factor**. THESL have set the Duty Factor to unity which is in line with the CNAIM HV Switchgear (GM) – Distribution model. The CNAIM HV Switchgear (GM) – Primary model includes the number of operations (normal or high). THESL may wish to consider the inclusion of number of operations or the identification of auto-reclosers as a proxy for high operations.

Health Score Modifier

In the CNAIM HV Switchgear (GM) models, a Health Score Modifier is created for each asset based on observed and measured condition results.

The condition inputs that have been included in THESL's 4kV oil circuit breaker model and the derivation of the respective factors are discussed in the sections below. It is assumed that the resulting observed and measured condition factors have been combined using the Maximum and Multiple Increment technique using the same calibration settings as in the CNAIM HV Switchgear (GM) models. However, it is noted that the derivation of the Health Score Factor may not be working correctly; there is only one asset (equipment number 000000031718) that has a Measured Condition Factor > 1 but the resulting Health Score Factor appears to take no account of this.

Observed Condition Modifier

The 4kV oil circuit breaker asset health model incorporates five observed condition inputs as listed in Table AIII.1; the model includes inputs from the current inspection form A5 and the pre-2016 inspection form C3. These inputs differ from the observed condition inputs in the CNAIM HV

\(^*\) 4kV CB_ACA Model_Output.xlsx (provided by THESL on 17 October 2017)

\(^†\) 4kV Oil CB ACA Model Considerations.docx (provided by THESL on 17 October 2017)
Switchgear (GM) models and, instead, THESL have made good use of available and relevant information to this asset group. The approach to mapping the data inputs to the measured condition factors is logical and has been documented in a transparent manner.

<table>
<thead>
<tr>
<th>Condition Input</th>
<th>Inspection Form A5 (from 2016)</th>
<th>Inspection Form C3 (pre-2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Condition (Corrosion)</td>
<td>Corrosion deficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corrosion level</td>
<td></td>
</tr>
<tr>
<td>Insulation Condition</td>
<td>Breaker mechanical condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil tank deficiency</td>
<td></td>
</tr>
<tr>
<td>Contacts &amp; Circuit Interruption Condition</td>
<td>Arc extinguishing deficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary contact deficiencies</td>
<td>Moving primary contact deficiency</td>
</tr>
<tr>
<td></td>
<td>Arcing contact deficiency</td>
<td>Primary contact alignment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fixed arcing contact deficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arcing contact alignment</td>
</tr>
<tr>
<td>Breaker Trip Condition</td>
<td>Trip mechanism deficiency</td>
<td>Trip deficiency</td>
</tr>
<tr>
<td></td>
<td>Charging mechanism deficiency</td>
<td>Spring release mechanism deficiency</td>
</tr>
<tr>
<td>Breaker Closing Condition</td>
<td>Close mechanism deficiencies</td>
<td>Contact springs deficiency</td>
</tr>
<tr>
<td></td>
<td>Anti-pump operation deficiencies</td>
<td>Latches deficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drive rods deficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guide rods deficiency</td>
</tr>
</tbody>
</table>

The observed condition calibration settings and the application of condition collars appear to be reasonable, with the weightings set to reflect the relative significance of the deficiencies in terms of THESL’s intervention / replacement activity.

It has been assumed that the Observed Condition Factor is derived using the MMI technique with the same settings as in the CNAIM HV Switchgear (GM) models (i.e. a maximum number of combined factors of 3). This high-level review could not verify that the MMI calculation is working correctly as random sampling of the Observed Condition Factor (Column E1 on the Raw Data tab) does not always produce the expected result (e.g. equipment numbers 000000031690 and 000000032136). However, it is recognised that THESL may have applied additional logic that is not specified in the documentation that has been provided.

**Measured Condition Modifier**

THESL have included insulation resistance deficiency and contact resistance deficiency as measured condition inputs in their 4kV oil circuit breaker model. These inputs seem appropriate for this asset class.

The measured condition calibration settings and the application of condition collars for code 103 (partially repaired – follow up) appear to be reasonable, with the weightings set to reflect the relative significance of the deficiencies in terms of THESL’s intervention / replacement activity.

* A5_Observed Conditions and C3_Observed Conditions tabs in 4kV CB_ACA Model_Output.xlsx
Reliability Modifier

THESL have not included the Reliability Modifier in their 4kV oil circuit breaker model. If any issues affecting particular groups of assets become apparent in the future, then the Reliability Modifier would be an appropriate place to capture and utilise this knowledge. However, it must be noted that the reliability input values directly impact the asset health score and, as such, their use must be justifiable.

Current Health Score

In THESL's 4kV oil circuit breaker model, the Current Health Score of an individual asset is determined from its Initial Health Score adjusted by the Health Score Factor, subject to the upper and lower thresholds defined by the Health Score Cap and Health Score Collar. The derivation is the same as described in the Common Network Asset Indices Methodology document.

The Current Health Score is a measure of the remaining useful life of an asset. As already stated, the expected service life is too low given the age of the 4kV oil circuit breaker population in the model and, hence, the model is underestimating their remaining useful lives. The corresponding Health Index Profile shows almost 70 percent of the assets to be in HI3; this is primarily driven by the expected service life that has been used and is unlikely to be providing an accurate reflection of the asset health of the population of 4kV oil circuit breakers.
Appendix IV Wood Poles

This Appendix provides a high-level review of THESL's wood pole model based on the model output spreadsheet as provided by Toronto Hydro. The review is based on the CNAIM OHL Support - Poles models. Observations are provided on the implementation of the CNAIM methodology, including the data inputs used, the calibration settings and the calculated health scores.

Initial Health Score

The Initial Health Score of an asset is based on the age of the asset, the normal expected service life of assets in that asset class, asset location and an approximate indication of asset duty or work load.

The following observations have been made about the inputs used in THESL's wood pole model:

- *Expected service life.* The THESL model uses an expected service life of 45 years compared with a normal expected life of 55 years for wood poles in the CNAIM OHL Support – Poles models. The average age of THESL's wood pole population is just over 32 years and a third of the assets are over 45 years old and hence, the expected service life used in the model is regarded as reasonable. If THESL are aware of any significant differences between different species of wood or different manufacturing periods, these could be incorporated into the model in the future.

- *Location Factor.* THESL have set the Location Factor to 1 which is in line with the value for wood poles in the CNAIM OHL Support – Poles models.

- *Duty Factor.* In the CNAIM OHL Support – Poles models, the Duty Factor is set to unity. THESL have adopted the same approach.

Health Score Modifier

In the CNAIM OHL Support – Poles models, a Health Score Modifier is created for each asset based on observed and measured condition results.

The condition inputs that have been included in THESL’s wood pole model and the derivation of the respective factors are discussed in the sections below. The resulting observed and measured condition factors have been combined using the Maximum and Multiple Increment technique using the same calibration settings as in the CNAIM models.

Observed Condition Modifier

The CNAIM OHL Support – Poles models incorporate four observed condition inputs as follows:

1. visual pole condition;
2. pole top rot;
3. pole leaning; and
4. bird / animal damage.

THESL have included all of the above inputs in their wood pole model. In addition, they have included pole cracks which is regarded as an appropriate input for this asset class.

The observed condition calibration settings and the application of condition caps and collars in THESL's wood pole model are similar to those in the CNAIM OHL Support – Poles models. The Observed Condition Factor is derived using the MMI technique and a maximum of 3 condition factors. This compares with using a maximum of 2 factors in the CNAIM OHL Support – Poles models but is regarded as reasonable given that THESL's model includes an additional condition input.

*Wood Poles Model_Output.xlsx* (provided by THESL on 20 October 2017)

116410 THESL Asset Condition Assessment Review Version 2.0 Final

17 November 2017
It has been noted that the MMI calculation does not appear to be working correctly where the Crack Deficiency is >1 and the other four condition deficiencies are equal to 1. As a result, there are more than 10,000 assets with an Observed Condition Factor of 1 rather than 1.15.

**Measured Condition Modifier**

The CNAIM OHL Support – Poles models incorporate a single measured condition input relating to the degree of pole decay / deterioration. THESL have included the same measure and have mapped % strength to four bands corresponding to the descriptions and calibration settings for the CNAIM pole decay / deterioration condition modifier.

The Pole Decay / Deterioration Factor has been applied† as stated in the calibration table in the output provided‡. However, it has been noted that different % strength bands have been used to set the Pole Decay / Deterioration Cap and Collar values as shown in Table AIV.1. It is important that the same definitions and % strength bands are used to set the Pole Decay / Deterioration Factor and the associated Cap and Collar; it is likely that the settings applied in THESL’s model will have a significant impact on the Measured Condition Modifier§.

### Table AIV.1 Pole Decay / Deterioration Modifier Settings in THESL’s Wood Pole Model

<table>
<thead>
<tr>
<th>Degree of Decay/Deterioration</th>
<th>% Strength</th>
<th>Pole Decay Factor</th>
<th>% Strength</th>
<th>Pole Decay Cap</th>
<th>% Strength</th>
<th>Pole Decay Collar</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>&gt;95%</td>
<td>0.8</td>
<td>≥85%</td>
<td>5.4</td>
<td>≥75%</td>
<td>0.5</td>
</tr>
<tr>
<td>No Significant Decay/Deterioration</td>
<td>80-95%</td>
<td>1</td>
<td>75-85%</td>
<td>6.4</td>
<td>≥75%</td>
<td>0.5</td>
</tr>
<tr>
<td>High</td>
<td>67%-80%</td>
<td>1.3</td>
<td>&lt;75%</td>
<td>10</td>
<td>65-75%</td>
<td>5.5</td>
</tr>
<tr>
<td>Very High</td>
<td>&lt;67%</td>
<td>1.5</td>
<td>&lt;75%</td>
<td>10</td>
<td>&lt;65%</td>
<td>8</td>
</tr>
</tbody>
</table>

The % strength band corresponding to a very high degree of decay / deterioration is probably set too high; more than 18,000 assets fall into this category (including 100 poles that have been installed in the past 3 years) resulting in around 25 percent of the population having a ‘forced’ minimum Health Score of 8.

**Reliability Modifier**

All of the CNAIM models include a Reliability Modifier to account for any reliability issues affecting an asset or family of assets that cannot be appropriately reflected by the Location and Duty Factors or detected in the condition assessment. THESL have not included the Reliability Modifier in their wood pole model and this is regarded as appropriate for this asset class.

**Current Health Score**

In THESL's wood pole model, the Current Health Score of an individual asset is determined from its Initial Health Score adjusted by the Health Score Factor, subject to the upper and lower thresholds defined by the Health Score Cap and Health Score Collar. The derivation is the same as described in the Common Network Asset Indices Methodology document.

Around 23,000 assets have a Current Health Score ≥8, indicating that one third of the wood pole population is at end-of-life. This appears high and is probably due to the way in which the % strength bands have been set in the derivation of the Measured Condition Modifier.

---

* e.g. Table 186; DNO Common Network Asset Indices Methodology Version 1.1, Ofgem, 30/01/2017
† The setting for no degree of decay / deterioration (zero measured loss of strength) is specified as ≥95% but it has been applied as >95%, thus overstating the Pole Decay / Deterioration Factor for around 3,000 assets
‡ Measured Condition tab in Wood Poles Model Output v2.xlsx
§ As there is only one measured condition input, the Measured Condition Modifier values are the same as the Pole Decay / Deterioration Modifier values.
From: Harishkumar Subramani  
Sent: November-15-17 10:11 AM  
To: Andrew Harrison; Linda Hull; Tracy Pears  
Cc: Lolu Agboola; Michael Tat; Chris Scarpelli  
Subject: RE: New definitions for Health index buckets

Thanks for your feedback Andy, I will have a discussion with the team and get back to you on this.

Regards,
Harish.

From: Andrew Harrison [mailto:Andrew.Harrison@eatechnology.com]  
Sent: November-15-17 9:50 AM  
To: Harishkumar Subramani ; Linda Hull ; Tracy Pears  
Cc: Lolu Agboola ; Michael Tat ; Chris Scarpelli  
Subject: RE: New definitions for Health index buckets

Hello Harish,
I'm fairly certain that I did respond to this email following my trip to Italy – That said I now have a new laptop and cannot search through the archives to forward my reply!

The definitions that you have put forward appear to be workable – however I would make the following comments:
1/ if the HI bucket definition is such that someone is required to take action then clearly state it. "may require assessment" is too washy, and you may wish to be more prescriptive.
2/ You will need to consider how you will advise / train substation and asset inspectors what minor/moderate and material deterioration looks like – this follows on from my first point about being clear, and avoiding the need for interpretation.
3/ HI4 "consider intervention” again too washy for me – would “initiate intervention planning” be a better choice of words?

I hope this helps?
Kind regards,
Andi

From: Harishkumar Subramani [mailto:HSubramani@TorontoHydro.com]  
Sent: 15 November 2017 14:10  
To: Andrew Harrison <Andrew.Harrison@eatechnology.com>; Linda Hull <Linda.Hull@eatechnology.com>; Tracy Pears <Tracy.Pears@eatechnology.com>  
Cc: Lolu Agboola <LAGboola@TorontoHydro.com>; Michael Tat <mtat@torontohydro.com>; Chris Scarpelli <cscarpelli@torontohydro.com>  
Subject: RE: New definitions for Health index buckets

Hello Andy,

Just a friendly reminder, Please review the below mentioned and provide us with your feedback.
Thanks,

Harish.

From: Harishkumar Subramani
Sent: November-01-17 10:29 AM
To: Andrew Harrison <Andrew.Harrison@eatechnology.com>; Linda.Hull@eatechnology.com; Tracy.Pears@eatechnology.com
Cc: Lolu Agboola <LAgboola@TorontoHydro.com>; Michael Tat <mtat@torontohydro.com>; Chris Scarpelli <cscarpelli@torontohydro.com>
Subject: New definitions for Health index buckets

Hello Andy,

As per our discussion in the last call we came up with new set of definitions for the Health Index buckets. Please review the list and let us know if this can be implemented to the new TH-CNAIM model.

<table>
<thead>
<tr>
<th>Band</th>
<th>Score</th>
<th>Definition</th>
<th>New definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI1</td>
<td>0.5&lt;4</td>
<td>New or as new condition</td>
<td>New or good condition</td>
</tr>
<tr>
<td>HI2</td>
<td>4&lt;5.5</td>
<td>Good or serviceable condition</td>
<td>Minor deterioration in serviceable condition, may require assessment</td>
</tr>
<tr>
<td>HI3</td>
<td>5.5&lt;6.5</td>
<td>Deterioration- require assessment and monitoring</td>
<td>Moderate deterioration, require assessment and monitoring</td>
</tr>
<tr>
<td>HI4</td>
<td>6.5&lt;8</td>
<td>Material deterioration, consider intervention</td>
<td>Material deterioration, consider intervention</td>
</tr>
<tr>
<td>HI5</td>
<td>8&lt;=10</td>
<td>End of life intervention required</td>
<td>End of life, intervention required</td>
</tr>
</tbody>
</table>

Regards,

Harishkumar Subramani, M.Eng
Project Analyst, Engineering Planning

Toronto Hydro Electrical Systems Limited.
500 Commissioners St, Toronto, ON M4M 1B4.
P: 4165423100 Ext. 59701
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RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 45:
Reference(s): Appendix 2-AA

Please provide a revised version of Appendix 2-AA on an in-service addition basis.

RESPONSE:

Toronto Hydro forecasts in-service additions on an asset basis, not by capital program (please refer to Toronto Hydro’s response to interrogatory 2A-SEC-31). Please refer to Exhibit 2A, Tab 1, Schedule 2, Appendix 2-BA for the in-service additions from 2015 to 2020. The table below summarizes the total in-service additions from 2015 to 2024. Toronto Hydro’s response to interrogatory 1B-Staff-22 (b) provides the Fixed Asset continuity schedules, in Appendix 2-BA format, for 2021 to 2024.

Table 1: 2015-2024 Total In-service Additions ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>435.3</td>
<td>584.3</td>
<td>520.3</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 46:
Reference(s): Exhibit 2B, Section E2

Please provide in a single table, broken down at the level provided in the evidence (for example see table 2 and 3):

a) Approved expenditures for each year between 2015 and 2019.

b) Actual/forecast expenditures for each year between 2014 and 2019.

c) The proposed expenditures for each year between 2020 and 2024.

RESPONSE:

In Appendix A to this response, Toronto Hydro has provided the information on the basis of total capital expenditures. As explained in Exhibit 2B, Section E4.1, the OEB’s envelope approval of capital related revenue requirement for the 2015-2019 CIR period did not include prescribed adjustments to the expenditure plans for specific programs or investment categories. The annual “2015 CIR (-10%)” expenditures in Appendix A were simply derived by applying a general 10% reduction to the annual capital expenditures filed in the 2015 to 2019 CIR application (EB-2014-0116).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 CIR Capital (-10%)</td>
<td>n/a</td>
<td>478.0</td>
<td>466.9</td>
<td>420.6</td>
<td>423.0</td>
<td>451.9</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Total Capital Spend</td>
<td>585.6</td>
<td>491.4</td>
<td>511.6</td>
<td>497.8</td>
<td>447.8</td>
<td>434.9</td>
<td>518.4</td>
<td>581.8</td>
<td>587.1</td>
<td>565.7</td>
<td>574.4</td>
</tr>
</tbody>
</table>
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 47:

Reference(s): Exhibit 2B, Section E2, p.2

Please explain the basis for each of the strategic parameters.

RESPONSE:

Toronto Hydro set the strategic parameters in order to be responsive to: the utility’s legal requirements including safety, customer feedback, and business input through expert analysis and professional judgment to develop construction and operations programs that address technical and operational requirements. Please also see Exhibit 2B, Sections E.2.1.1 and E.2.1.2, and Exhibit 1B, Tab 1, Schedule 1 at page 6.

As discussed in Exhibit 1B, Tab 3, Schedule 1, customers expressed that limiting price increases and specific performance outcomes were important to them. Both of these were also important to Toronto Hydro. To help operationalize these parameters, Toronto Hydro also expressed the price increase in approximate OM&A and CapEx terms as a third strategic parameter.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 48:
Reference(s): Exhibit 2B, Section E2, p.6

Please provide a copy of the ‘initial’ capital plan and the ‘penultimate’ capital plan.

RESPONSE:
Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-73 (a).
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 49:
Reference(s): Exhibit 2B, Section E2, p.1; EB-2014-0116

After the release of the Decision and Order in EB-2014-0116, please explain how Toronto Hydro planned to implement the Board’s reduction of the capital budget by 10%. Please provide a contemporaneous document showing how the reduction was forecasted to be allocated among proposed programs in the application.

RESPONSE:
The OEB’s envelope approval of the capital related revenue requirement for the 2015-2019 period did not include prescribed adjustments to the expenditure plans within specific programs or investment categories. As noted in Exhibit 2B, Section E4 at page 1, through normal course planning activities, Toronto Hydro managed to an overall five year budget which was in line with the OEB’s prescribed reduction at a total capital expenditure plan level.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 50:

Reference(s): Exhibit 2B, Section E4, p.2

Please revise Table 1 to show for ‘plan’, the internally budgeted amount for each given year.

RESPONSE:

Toronto Hydro declines to provide the requested information on the basis that it does not have probative value in deciding how the utility performed relative to the plan in the last application. The relevant information has been provided in the table referenced by the question. That table includes the CIR plan, which was approved by the OEB on envelope basis, as well as the actuals for the historical years (2015-2018) and the forecasts for the bridge years (2018-2019) by investment category. Toronto Hydro believes that this information is comprehensive, consistent with the Filing Requirements, and appropriate for the OEB to evaluate the utility’s execution of the 2015-2019 plan.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 51:
Reference(s): Exhibit 2B, Section E4

Please complete table included in the accompanying excel spreadsheet return in excel format.

RESPONSE:
Please refer to the populated Excel file “2B-SEC-51.xlsx”.

The Excel file was pre-populated by SEC with units for assets within the specified programs and asset class categories. Toronto Hydro reviewed and validated these units against what was presented within the EB-2014-0116 application (shaded in green). The one unit shaded in orange is a unit that Toronto Hydro has corrected. Toronto Hydro also populated units (shaded in light yellow) for the 2015-2019 actuals and forecast, and for the 2020-2024 proposed plan. Given that the EB-2014-0116 program view was used as a basis, and that program structure and approach has changed for the 2020-2024 proposed plan, Toronto Hydro was unable to comprehensively populate the file. Please see the following notes for additional details.

- Programs that replace units in a non like-for-like manner are a challenge to populate given that Toronto Hydro’s systems have historically not tracked the removal of assets in a manner that enables allocations to particular programs. Programs such as Rear Lot Conversion and Box Construction are examples of programs that are affected.
• Beginning with this EB-2018-0165 application, Toronto Hydro now projects the volume of Rear Lot conversion activities on a customer basis, rather than on a per asset basis. Tracking on a per customer basis has allowed Toronto Hydro to better track and monitor the changes to the customer experience in moving from the legacy rear-lot design to the new standardized underground distribution design. Similarly, Toronto Hydro now tracks Box Construction activities using the dominant unit of poles. These shifts mean that asset replacement units relating to these activities cannot be reconciled, in the manner contained in the file, to figures filed in EB-2014-0116.

• Certain investment programs from the EB-2014-0116 application, including Underground Legacy Infrastructure and Overhead Infrastructure Relocation, have not been carried over into the new EB-2018-0165 application. Associated investments in these instances have been integrated into other programs. For instance, replacement units for Overhead Infrastructure Relocation program have been integrated into the Overhead System Renewal program.

• Strategies and drivers for some programs have changed, which results in some units not being comparable across all years. For example, drivers for replacing PILC cables have changed in the period from 2020-2024, with the primary driver now being to replace PILC cables with standardized TRXLPE cables, as opposed to the historical 2015-2019 period, where PILC cables were replaced in a targeted manner if they were found to be in leaking condition.

• The organization of the file by specific asset type results in some accomplishments being left off of the file. For example, Network Circuit Reconfiguration not only installs network units, but also reconfigures entire networks. For example, EB-2014-
0116 included a plan to reconfigure 3 networks. The proposed 2020-2024 plan includes a plan to reconfigure 5 networks. This is not included in the file.

Please see Exhibit 2B, Section E6 generally for program specific variance explanations. For example, in Box Construction, it is notable that while 1,836 poles were originally planned to be replaced as per the EB-2014-0116 application, a total of 5,322 poles are actually forecasted to be replaced from 2015 onwards to 2019, representing a 190 percent increase in asset replacements. This increase in work is largely driven by incremental replacement of wood poles supporting secondary conductors and lateral connections, which were not included as part of the original 1,836 pole estimate. These poles, which were part of box construction feeders, also had to be replaced, such that Toronto Hydro could fully convert these locations to standardized infrastructure and ensure that customer expectations could be met following the completion of the work. Please note however that this incremental work was conducted cost efficiently, as actual costs incurred from 2015-2019 only increased by 17 percent.
## Program/Assets

### E6.1 Underground Circuit Renewal
- **Underground Switches**
  - 2015: 84
  - 2016: 71
  - 2017: 74
  - 2018: 88
  - 2019: 88
- **Underground Transformer**
  - 2015: 348
  - 2016: 291
  - 2017: 305
  - 2018: 362
  - 2019: 361
- **Underground Cable (circuit km)**
  - 2015: 150
  - 2016: 126
  - 2017: 132
  - 2018: 156
  - 2019: 156

### E6.2 Paper-Insulated Lead-Covered (PILC) Piece-outs and Leakers
- **PILC Cable (km)**
  - 2015: 5.39
  - 2016: 3.66
  - 2017: 2.59
  - 2018: 2.66
  - 2019: 0.7

### E6.3 Underground Legacy Infrastructure
- **Sachsenwerk Switch and Fuse Units**
  - 2015: 6
  - 2016: 12
  - 2017: 12
  - 2018: 10
  - 2019: 0
- **Powerlite Switches**
  - 2015: 0
  - 2016: 2
  - 2017: 2
  - 2018: 2
  - 2019: 2
- **Single Phase Submersible Transformers**
  - 2015: 0
  - 2016: 0
  - 2017: 4
  - 2018: 4
  - 2019: 4
- **Step Transformers**
  - 2015: 0
  - 2016: 0
  - 2017: 2
  - 2018: 2
  - 2019: 1
- **SF Switches**
  - 2015: 2
  - 2016: 1
  - 2017: 2
  - 2018: 1
  - 2019: 0
- **Cable Chamber Covers**
  - 2015: 25
  - 2016: 375
  - 2017: 375
  - 2018: 375
  - 2019: 350

### E6.4 Overhead Circuit Renewal
- **Poles**
  - 2015: 3332
  - 2016: 1735
  - 2017: 1900
  - 2018: 1934
  - 2019: 2313
- **Overhead Switches**
  - 2015: 294
  - 2016: 160
  - 2017: 166
  - 2018: 154
  - 2019: 207
- **Overhead Transformers**
  - 2015: 972
  - 2016: 511
  - 2017: 478
  - 2018: 478
  - 2019: 673

### E6.5 Overhead Infrastructure Relocation
- **Poles**
  - 2015: 32
  - 2016: 27
  - 2017: 8
- **OH Conductor (mts)**
  - 2015: 5656
  - 2016: 3400
- **OH Switches**
  - 2015: 10
  - 2016: 6
  - 2017: 6
- **OH Transformers**
  - 2015: 22
  - 2016: 1
- **Underground Cable Chamber**
  - 2015: 2
  - 2016: 18

### E6.6 Rear Lot Conversion
- **Pole**
  - 2015: 63
  - 2016: 218
  - 2017: 110
  - 2018: 31
  - 2019: 175
- **Transformer**
  - 2015: 33
  - 2016: 62
  - 2017: 48
  - 2018: 30
  - 2019: 40
- **Manual Switch**
  - 2015: 16
  - 2016: 14
  - 2017: 7
  - 2018: 5
  - 2019: 8
- **Fuse**
  - 2015: 13
  - 2016: 15
  - 2017: 16
  - 2018: 20
  - 2019: 19
- **Riser**
  - 2015: 13
  - 2016: 5
  - 2017: 6
  - 2018: 5
  - 2019: 22
- **Conductor (m)**
  - 2015: 1960
  - 2016: 9114
  - 2017: 4682
  - 2018: 1796
  - 2019: 7888
- **Cable (m)**
  - 2015: 4583
  - 2016: 4305
  - 2017: 5476
  - 2018: 5598
  - 2019: 1566

### E6.7 Box Construction Conversion
- **OH Transformer**
  - 2015: 201
  - 2016: 381
  - 2017: 86
  - 2018: 175
  - 2019: 77
- **OH Switch**
  - 2015: 162
  - 2016: 301
  - 2017: 70
  - 2018: 176
  - 2019: 85
- **Poles**
  - 2015: 407
  - 2016: 780
  - 2017: 277
  - 2018: 255
  - 2019: 117
- **UG Switch**
  - 2015: 0
  - 2016: 0
  - 2017: 0
  - 2018: 6
  - 2019: 0
- **UG Transformer**
  - 2015: 21
  - 2016: 27
  - 2017: 9
  - 2018: 52
  - 2019: 17
- **OH Conductor (km)**
  - 2015: 25.5
  - 2016: 46.2
  - 2017: 11.4
  - 2018: 24.4
  - 2019: 11.5
- **UG Cable (km)**
  - 2015: 2422
  - 2016: 2900
  - 2017: 3800

### E6.8 SCADA-MATE R1 Replacement
- **R1 Switch**
  - 2015: 72
  - 2016: 67
  - 2017: 57
- **RTU**
  - 2015: 52
  - 2016: 49
  - 2017: 14

### E6.9 Network Vault Rebuild Program
- **Vaults**
  - 2015: 6
  - 2016: 9
  - 2017: 9
  - 2018: 9
  - 2019: 9
- **Roofs**
  - 2015: 4
  - 2016: 2
  - 2017: 2
  - 2018: 3
  - 2019: 4
- **UG Network Units**
  - 2015: 11
  - 2016: 18
  - 2017: 17
  - 2018: 20
  - 2019: 20

### E6.10 Network Unit Renewal Program
- **Network Unit (Transformer and Protector)**
  - 2015: 40
  - 2016: 50
  - 2017: 50
  - 2018: 50
  - 2019: 50

### Notes
- See Network Unit (Transformer and Protector) for additional data.
- Remaining locations to be addressed through Overhead System Renewal.
- Remaining locations to be addressed through Underground System Renewal.
- See Notes. 2,090 customer conversions.
<table>
<thead>
<tr>
<th>Program/Assets</th>
<th>EB-2014-0116 Application Numbers Verified</th>
<th>EB-2014-0116 Application Numbers Unverified &amp; Corrected Accordingly within this IR Response</th>
<th>Data Populated</th>
</tr>
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<tbody>
<tr>
<td>E6.11 Legacy Network Equipment Replacement (ATS &amp; RPB)</td>
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<tr>
<td>ATS</td>
<td>3  2  3  2  3</td>
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<td>RPB</td>
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<td>5  5  3  0  0</td>
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<td>E6.12 Network Circuit Reconfiguration</td>
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<td>UG Transformers (600 V Network)</td>
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<td>TS Switchgear</td>
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<td>0  0  1  1  1</td>
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<td>MS Switchgear</td>
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<td>2  0  4  4  1</td>
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<td>Power Transformers</td>
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<td></td>
</tr>
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</tr>
<tr>
<td>KSO Oil Circuit Breaker</td>
<td>10 6 6 7 6</td>
<td>4  2 5 11 6</td>
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<td>E6.16 Stations Control &amp; Monitoring</td>
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<td>Etobicoke RTU Replacement (MOSCAD)</td>
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<td>1  5  7  6  5</td>
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<td>Downtown RTU Replacement (DACSCAN)</td>
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<td>E6.17 Stations Ancillary Systems</td>
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<tr>
<td>Air Compressors</td>
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</tr>
<tr>
<td>Station Service Power Supply</td>
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<td>Fire Alarm System</td>
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<tr>
<td>Fire Barrier/Suppression System</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E6.18 Stations Buildings</td>
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<tr>
<td>E6.19 Stations DC Battery Replacement</td>
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</tr>
<tr>
<td>Battery System 50 Ah</td>
<td>2  8  5  6  5</td>
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<td></td>
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<tr>
<td>Battery System 80 Ah</td>
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</tr>
<tr>
<td>Battery System 105 Ah</td>
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<tr>
<td>Battery System 200 Ah</td>
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</tr>
<tr>
<td>Battery System 300 Ah</td>
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<td>Battery System 400 Ah</td>
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<td>E6.20 Reactive Capital</td>
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<td>Smart Meters</td>
<td>3990 3930 3930 3930 3930</td>
<td>1247 3004 4058 5350 3930</td>
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<tr>
<td>RMS</td>
<td>88 88 88 88 88</td>
<td>108 66 55 178 88</td>
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<tr>
<td>Quadrilog</td>
<td>1067 1157 1257 1357 1457</td>
<td>11004 2213 1117 1172 1457</td>
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<td>Primary Metering Units</td>
<td>8  10 10 10 10</td>
<td>3  23 6 8 10</td>
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<td>E6.21 Worst Performing Feeder</td>
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<td>E6.22 Distribution System Communication Infrastructure</td>
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<tr>
<td>IP Data Network Retrofit (SONET Multiplexers to be augmented with)</td>
<td>34 11</td>
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</tr>
<tr>
<td>IP Data Network Installation (Without SONET technology Present)</td>
<td>34</td>
<td></td>
<td></td>
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<tr>
<td>Number of sites</td>
<td></td>
<td></td>
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<tr>
<td>Fiber-Optic Ring Fiber replacement in Toronto (km)</td>
<td>72</td>
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<td></td>
</tr>
<tr>
<td>Fiber-Optic Ring Fiber replacement in Scarborough (km)</td>
<td>45</td>
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<td></td>
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<tr>
<td>Fiber-Optic Ring Expansion in Toronto (km)</td>
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<td></td>
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<tr>
<td>Fiber-Optic Ring Expansion in Scarborough (km)</td>
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<td></td>
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<td>New Wireless SCADA SD9 High Site Deployment (# of Sites)</td>
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<td>Wireless SCADA GE Transit to GE SD9 Endpoint Radio Equipment Migration (# of Radios)</td>
<td>194 289</td>
<td></td>
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</tbody>
</table>

**Please complete the shaded era**
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 52:
Reference(s): Exhibit 2B, Section E4

Please complete table included in the accompanying excel spreadsheet return in excel format.

RESPONSE:
Please see the Excel spreadsheet entitled “2B-SEC-52.xlsx”.

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
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<td>80.10</td>
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<td>99.50</td>
<td>115.49</td>
<td>80.68</td>
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<td>3.45</td>
<td>6.69</td>
<td>6.64</td>
<td>6.48</td>
<td>5.52</td>
<td>7.43</td>
<td>9.88</td>
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<td>E6.3 Underground Legacy Infrastructure</td>
<td>2.06</td>
<td>2.30</td>
<td>24.90</td>
<td>25.30</td>
<td>30.30</td>
<td>61.00</td>
<td>51.02</td>
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<td>E6.4 Overhead Circuit Renewal</td>
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<td>1.38</td>
<td>1.83</td>
<td>2.82</td>
<td>3.64</td>
<td>89.79</td>
<td>9.34</td>
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<td>E6.5 Overhead Infrastructure Relocation</td>
<td>17.05</td>
<td>8.06</td>
<td>10.30</td>
<td>10.30</td>
<td>13.60</td>
<td>26.77</td>
<td>13.65</td>
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<td>E6.6 Box Construction Conversion</td>
<td>17.80</td>
<td>20.70</td>
<td>21.10</td>
<td>21.60</td>
<td>22.70</td>
<td>19.59</td>
<td>13.65</td>
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<td>E6.7 SCADA-MATE R1 Replacement</td>
<td>6.16</td>
<td>4.11</td>
<td>2.68</td>
<td>2.74</td>
<td>3.40</td>
<td>3.50</td>
<td>4.88</td>
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<tr>
<td>E6.8 Network Vault Rebuild Program</td>
<td>3.95</td>
<td>10.17</td>
<td>10.29</td>
<td>10.25</td>
<td>10.24</td>
<td>4.55</td>
<td>8.03</td>
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<td>3.95</td>
<td>10.37</td>
<td>10.29</td>
<td>10.25</td>
<td>10.24</td>
<td>4.72</td>
<td>7.64</td>
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<td>E6.10 Legacy Network Equipment Replacement (ATS &amp; RPB)</td>
<td>0.45</td>
<td>0.98</td>
<td>1.14</td>
<td>0.91</td>
<td>1.14</td>
<td>0.98</td>
<td>1.09</td>
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<td>2.28</td>
<td>2.27</td>
<td>0.00</td>
<td>0.74</td>
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<tr>
<td>E6.12 Stations Switchgear Renewal</td>
<td>11.90</td>
<td>18.90</td>
<td>25.50</td>
<td>27.60</td>
<td>22.40</td>
<td>7.70</td>
<td>5.51</td>
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<td>E6.13 Stations Power Transformer Renewal</td>
<td>1.86</td>
<td>3.98</td>
<td>5.84</td>
<td>3.93</td>
<td>4.12</td>
<td>2.28</td>
<td>3.06</td>
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<tr>
<td>E6.14 Stations Circuit Breaker Renewal</td>
<td>1.66</td>
<td>1.80</td>
<td>1.79</td>
<td>2.11</td>
<td>1.78</td>
<td>2.28</td>
<td>2.50</td>
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<td>E6.15 Stations Control &amp; Monitoring</td>
<td>0.08</td>
<td>0.94</td>
<td>1.11</td>
<td>1.49</td>
<td>1.44</td>
<td>0.32</td>
<td>1.34</td>
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<tr>
<td>E6.16 Stations Ancillary Systems</td>
<td>0.69</td>
<td>0.59</td>
<td>0.37</td>
<td>0.26</td>
<td>0.38</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>E6.17 Stations Buildings</td>
<td>2.50</td>
<td>2.50</td>
<td>2.30</td>
<td>2.60</td>
<td>1.30</td>
<td>3.20</td>
<td>2.80</td>
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<tr>
<td>E6.18 Stations DC Battery Replacement</td>
<td>0.27</td>
<td>0.67</td>
<td>0.71</td>
<td>0.74</td>
<td>0.73</td>
<td>0.12</td>
<td>0.82</td>
</tr>
<tr>
<td>E6.19 Stations DC Battery Replacement</td>
<td>21.90</td>
<td>31.70</td>
<td>33.10</td>
<td>33.60</td>
<td>34.20</td>
<td>38.99</td>
<td>50.19</td>
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<tr>
<td>E6.20 Reactor Circuit</td>
<td>4.80</td>
<td>4.80</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</table>

Please complete the shaded era
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 53:

Reference(s): Exhibit 2B, Section E4

Please provide a list of material capital projects that have gone into service/forecast to go into-service between 2015 and 2019, or were previously forecasted to go in-service between 2015 and 2019. Please include the following information for each project:

a) Name of the project

b) Type of project/brief description of the project

c) Year the project was originally forecasted to go in-service

d) Year the project went in-service or is now forecasted to go in-service

e) Originally approved budget for the project

f) Actual cost of the project or revised forecasted cost

g) Explanation for any variance in cost if actual/revised forecast is +/- 5% of the original budget amount

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-75 parts (c) and (d).
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 54:
Reference(s): Exhibit 2B, Section E5.1, p.12

With respect to forecast energy storage connections, please provide the specific information that Toronto Hydro is relying on for the forecast number of connections/capacity.

RESPONSE:
Please see Table 1 below:

Table 1: Energy Storage Forecast Breakdown

<table>
<thead>
<tr>
<th>Type</th>
<th>Unit Capacity (MW)</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro ESS</td>
<td>0.006</td>
<td>Units</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>22</td>
<td>27</td>
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<td></td>
<td></td>
<td>MW</td>
<td>0.08</td>
<td>0.11</td>
<td>0.13</td>
<td>0.15</td>
<td>0.19</td>
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<td>Small ESS</td>
<td>0.4</td>
<td>Units</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
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<td>2.4</td>
<td>3.2</td>
<td>4.0</td>
<td>4.8</td>
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<td>Mid ESS</td>
<td>2</td>
<td>Units</td>
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<td>4</td>
<td>5</td>
<td>6</td>
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<td>8.0</td>
<td>10.0</td>
<td>12.0</td>
<td>14.0</td>
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RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 55:
Reference(s): Exhibit 2B, Section E5.2, p.7

Please breakdown Table 4 by major project.

RESPONSE:

Tables 1 to 5 below breakdown the referenced table by major project as identified in Exhibit 2B, Section 5.2.4.1. Please note that Table 4 in Exhibit 2B, Section E5.2 at page 7 encompasses expenditures for all projects including small and medium relocation and expansion work. As such, the sum of the expenditures in the tables below will not amount to the 2015-2019 or 2020-2024 program costs.

<table>
<thead>
<tr>
<th>Table 1: Metrolinx Eglinton Crosstown LRT Costs ($ Millions)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Total</td>
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<tr>
<td>Capital Contributions</td>
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<tr>
<td>Net</td>
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<table>
<thead>
<tr>
<th>Table 2: Metrolinx Finch West LRT Costs ($ Millions)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Total</td>
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<tr>
<td>Capital Contributions</td>
</tr>
<tr>
<td>Net</td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
Table 3: Metrolinx Regional Express Rail Costs ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
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</thead>
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<tr>
<td>Total Cost</td>
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<td>0.02</td>
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</tr>
<tr>
<td>Capital Contributions</td>
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</tr>
<tr>
<td>Net</td>
<td>0</td>
<td>0.02</td>
<td>0.03</td>
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</tbody>
</table>

Table 4: TTC Easier Access Program Costs ($ Millions)¹

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
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<td>0.55</td>
<td>0.38</td>
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<tr>
<td>Capital Contributions</td>
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<td>(0.36)</td>
<td>(1.0)</td>
</tr>
<tr>
<td>Net</td>
<td>0.44</td>
<td>0.19</td>
<td>(0.63)</td>
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Note 1: As no commitment had been made at the time of the filing, there were no expenditures included in the 2020-2024 program costs.

Table 5: City of Toronto Projects Costs ($ Millions)¹

<table>
<thead>
<tr>
<th>Projects</th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
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<tbody>
<tr>
<td>John Revitalisation</td>
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<tr>
<td>Capital Contributions</td>
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</tr>
<tr>
<td>Net</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington Street</td>
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<tr>
<td>Capital Contributions</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>York-Bay-Yonge</td>
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<td></td>
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<tr>
<td>Capital Contributions</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net</td>
<td>0</td>
<td>0</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Note 1: As no commitment had been made for the Harbour Street Widening at the time of the filing, there were no expenditures included in the 2020-2024 program costs. Subsequent to the application filing, the Harbour Street Widening project was cancelled.

Panel: Distribution System Capital and Maintenance
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 56:
Reference(s): Exhibit 2B, Section E5.4, p.14

On the same basis as Tables 5-6, please provide the number of meters per year by category.

RESPONSE:

Please see Table 1 and Table 2 below.

Table 1: 2015-2019 Meter Volumes

<table>
<thead>
<tr>
<th></th>
<th>Actuals</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2016</td>
<td>2017</td>
<td>2018</td>
<td>2019</td>
<td>Total</td>
</tr>
<tr>
<td>Residential and Small C&amp;I Meters</td>
<td>7,166</td>
<td>17,612</td>
<td>25,333</td>
<td>16,512</td>
<td>13,569</td>
<td>80,192</td>
</tr>
<tr>
<td>Suite Meters</td>
<td>9,724</td>
<td>6,447</td>
<td>5,387(^1)</td>
<td>5,725</td>
<td>5,500</td>
<td>32,783</td>
</tr>
<tr>
<td>Large User and Interval Meters</td>
<td>174</td>
<td>215</td>
<td>856</td>
<td>1,114</td>
<td>790</td>
<td>3,149</td>
</tr>
<tr>
<td>Wholesale Meters</td>
<td>138</td>
<td>6</td>
<td>109</td>
<td>85</td>
<td>10</td>
<td>348</td>
</tr>
</tbody>
</table>

\(^1\) Please note that Figure 1 in Exhibit 2B, Section E5.4 showed a preliminary 2017 number for suite meters of approximately 4,000. The finalized number is 5,387.

Table 2: 2020-2024 Meter Volumes

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2021</td>
<td>2022</td>
<td>2023</td>
<td>2024</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Residential and Small C&amp;I Meters</td>
<td>706</td>
<td>384</td>
<td>52,408</td>
<td>103,035</td>
<td>155,455</td>
<td>311,978</td>
<td></td>
</tr>
<tr>
<td>Suite Meters</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
<td>27,500</td>
<td></td>
</tr>
<tr>
<td>Large User and Interval Meters</td>
<td>17</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>33</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Wholesale Meters</td>
<td>24</td>
<td>8</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

Panel: Distribution System Capital and Maintenance
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 57:
Reference(s): Exhibit 2B, Section E6.1, p. 1

Does Toronto Hydro’s Rear Lot Conversion program include converting the rear lot that may be assessable by backyard laneway? If so, please explain why and provide details of how much of the real lot conversion program is made up of this type of conversion.

RESPONSE:
None of the planned Rear Lot Conversion areas have an accessible backyard laneway.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 58:

Reference(s): Exhibit 2B, Section E6.1, p. 17

With respect to Figure 12, ‘Root Cause Distribution or Failed Underground Transformers’:

a) What is meant by an ‘end of life’ failure?

b) Does a failure classified as ‘end of life’ include failures that if not for the asset’s age, would be classified in one of the other categories?

c) Please explain what is included in the ‘other’ category.

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 4B-HANN-128 for failure root cause categories and definitions.

b) No, ‘end of life’ failures do not include failures that have been investigated and determined to have a root cause from one of the other categories.

c) The ‘other’ category in Figure 12, Exhibit 2B, Section E6.2, page 17 includes asset failures resulting from various root cause categories such as overloading, overvoltage, lightning strike, process, etc. Please refer to Toronto Hydro’s response to interrogatory 4B-HANN-128 for failure root cause categories and definitions.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 59:

Reference(s): Exhibit 2B, Section E6.2, p.31-33

For many of the various system renewal programs, Toronto Hydro presents a number of different options for the program as a whole, or certain assets within the program. SEC seeks to understand the development and considerations of these options. Using Underground System Renewal – Horseshoe program as an example:

a) Please explain how and when each of these options was developed.

b) Please explain what type of analysis went into the development of each of these options and how the options were presented to the decision-maker.

c) Please provide a copy of the analysis that was provided to the decision-maker who ultimately selected option 3.

d) Is the process described in part (a) and (b) consistent with the process for other system renewal investment? If no, please explain the more common process.

RESPONSE:

a) Toronto Hydro developed the options by analyzing the needs of the underground system (including risks) and identifying combinations of investment approaches (e.g. spot replacements, area rebuilds) and paces (i.e. more or less investment) that are
available to address those needs. Please see part (b) for details on the type of analysis that was conducted.

The development of the options for programs (including those in the Underground System Renewal – Horseshoe program) began at the portfolio plan stage of Toronto Hydro’s Investment Planning and Portfolio Reporting (IPPR) process, described in Exhibit 2B, Section D1.2.1. Please see Toronto Hydro’s response to interrogatory 2B-SEC-34 for a chronology of events. As noted in 2B-SEC-34, the portfolio plan stage began in early 2017, and was refined during the broader operational and financial planning activities.

b) The type of analysis that was conducted focused on developing options that would address the underground system’s needs. As detailed in Exhibit 2B, Section 6.2.3, the underground system’s needs include managing the presence of legacy direct buried cables and their increased failure risk (see Section 6.2.3.1), and eliminating the risk of PCB oil spills (see Section 6.2.3.2) from transformers. During the development of initial options at the IPPR stage (referenced in part (a)), options focused on pacing (i.e. renewing greater numbers of assets vs. renewing fewer assets) and examining the implications of different paces on outcomes (such as, reliability, oil leaks and PCBs, and condition), while considering insights being gathered about customer preferences from customer engagement activities.

As capital planning continued and Toronto Hydro moved into the development of the evidence, options were further refined. Where prudent, options were expanded following analysis that included considerations beyond pacing. That refinement and expansion was informed by insights that Toronto Hydro’s planners have gained at the Scope and Project Development stage (described in Exhibit 2B, Section D.1.2.2) of the
AM Process. When developing particular scopes of work, planners consider detailed technical and engineering options (e.g. renew like-for-like or renew using a different configuration).

The options presented as part of the Underground System Renewal – Horseshoe program were developed using the analysis that is summarized above. At every step of that development, decision makers were reviewing the analysis. For example, senior management panels reviewed the analyses that were conducted at the IPPR stage (as referenced above in part (a)) and extensive reviews were conducted of the evidence that was developed and ultimately filed as part of Toronto Hydro’s application.

c) The option analysis provided is documented in Exhibit 2B, Section E6.2.5.

d) Yes, the process described in parts (a) and (b) was consistent for all system renewal investments.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 60:
Reference(s): Exhibit 2B, Section E6.3, p.28-29

Please reconcile the statement in the evidence: “Toronto Hydro has applied these volumetric costs to the forecast population of critical cables to develop the 2020-2024 segment cost of $63 million”, with the forecast cost of $89.7M shown in Table 7.

RESPONSE:
As noted in Toronto Hydro’s response to 2B-Staff-73 (a), the utility increased the amount of planned investment in the Underground System Renewal – Downtown program between the penultimate and final plans to address approximately 15 km of additional high-risk lead cable. As demonstrated in the results on page 16 of the Customer Engagement report, there was strong support for lead cable replacement, including a plurality of support in the lower volume customer classes for accelerating the rate of replacement (Exhibit 1B, Tab 3, Schedule 1, Appendix A). Due to a drafting oversight, the text on page 29 of the evidence referenced by this interrogatory was not updated to reflect this change.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 61:

Reference(s): Exhibit 2B, Section E6.4, p.22

In the same format as Table 7, please provide the total units that were or are planned to be replaced/renewed/reconfigured for each year between 2015 and 2024, broken down by program category.

RESPONSE:

Please see Table 1 below. Each unit for Legacy Network Equipment Renewal consists of either an ATS vault (i.e. one ATS), or an RPB vault (i.e. two RPBs). Each unit for Network Unit Renewal consists of a complete network unit (i.e. one network transformer complete with primary switch, plus one network protector). Each unit for Network Vault Renewal consists of either a decommissioned vault, a vault roof rebuild, or a complete vault rebuild. Each unit for Network Circuit Reconfiguration consists of either a planned reconfiguration of a complete network, or a 600 V network pilot project.
Table 1: Total Units Planned to be Replaced/Renewed/Reconfigured by Program

<table>
<thead>
<tr>
<th>Category</th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legacy Network Equipment Renewal (ATS &amp; RPB)</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Network Unit Renewal</td>
<td>17</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>Network Vault Renewal</td>
<td>11</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>Network Circuit Reconfiguration</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 62:
Reference(s): Exhibit 2B, Section E6.5

Please explain in detail how Toronto Hydro will execute the Overhead System Renewal program. For example, does a specific job/work in this program order consist of replacing a singular pole or transformer that requires replacing, or does it consist of geographic area where all poles, transformers, conductors etc. are replaced?

RESPONSE:
Details on how Toronto Hydro will execute the Overhead System Renewal program are provided in Exhibit 2B, Section E6.5.5.2.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 63:

Reference(s): Exhibit 2B, Section E6.6, p.48

Please explain the process to replace a TS Switchgear unit. Please also provide as an example, the schedule for a currently underway TS Switchgear replacement project.

RESPONSE:

The timeframe between project conceptualization and actual TS Switchgear replacement spans multiple years and can vary depending on project specific complexities. The process to replace a typical TS Switchgear unit can be separated into four distinct phases as outlined below.

Phase I - Project Conceptualization, Design, and Hydro One Coordination

Once a TS Switchgear unit has been identified as requiring replacement, Toronto Hydro’s planning department evaluates the station for suitable locations for a replacement switchgear. This is typically required because the criticality of the asset and other system constraints restrict it from being off-loaded and replaced in-place (with few exceptions).

When a suitable location has been identified, a conceptual design and proposal is prepared and submitted to Hydro One. Toronto Hydro and Hydro One coordinate through an engineering study and design phase and eventually execute an agreement outlining the scope of work required by each party to perform the replacement.
Phase II - Site Preparation (Construction Start)
In most cases, the location identified for the TS Switchgear replacement is not readily usable without first relocating minor (or unused) equipment or without first performing structural modifications. The site preparation phase can often be partially executed in parallel with the later stages of Phase I.

Phase III - Installation, Assembly, and Commissioning
After the site has been cleared and prepared, the new TS Switchgear unit is installed. A TS Switchgear unit is shipped as multiple cells which must be assembled once delivered to site. Crews assemble the switchgear and then perform various commissioning tests to verify functionality.

In the later stages of Phase III, Hydro One installs their own portion of the switchgear (the supply cells) and performs similar work, the cost of which Hydro One recovers from Toronto Hydro in the form of a capital contribution.

Phase IV - Energization and Load Transfer
A TS Switchgear is supplied via two Hydro One supply feeds. Once the new TS Switchgear has been installed, commissioned, and confirmed ready-for-energization, Toronto Hydro and Hydro One coordinate to energize the new unit. A detailed cut-over plan is developed in advance to manage and mitigate contingency risks created during the cut-over period (i.e. the period during which supply and load are transferred from the old switchgear to the new switchgear).

Without taking customer outages, Toronto Hydro and Hydro One coordinate to cut-over the first supply feed from the old TS Switchgear unit to the new TS Switchgear unit. For a period of time both the old unit and its replacement are each supplied by only one Hydro
One feed. During this period, Toronto Hydro transfers load from the old unit to the new unit. Following the load transfer, the second supply is cut-over such that the new TS Switchgear unit has two supply feeds and the old unit is no longer in-service. The project has been completed.

At the time of writing, Toronto Hydro has two TS Switchgear replacement projects well into their construction phases. The actual schedule for the Wiltshire TS A3-4W is provided below. This example has been chosen due to its maturity in the process.

**Phase I:** November 2010 – May 2014  
**Phase II:** January 2013 – December 2014  
**Phase III:** January 2015 – August 2018  
**Phase IV:** September 2018 – February 2019

![Wiltshire TS A3-4W TS Switchgear Replacement Schedule](image)

**Figure 1:** Wiltshire TS A3-4W TS Switchgear Replacement Schedule

Panel: Distribution System Capital and Maintenance
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 64:

Reference(s): Exhibit 2B, Section E6.7, p.9

With respect to Figure 4 showing the volume of reactive work:

a) Please provide the information in Figure 4 in a table format and update to include 2018 information.

b) If available, please provide a further breakdown of the number of reactive work requests into sub-categories of underground/overhead/stations.

RESPONSE:

a) The breakdown of reactive capital work requests is listed in Table 1 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Underground</th>
<th>Overhead</th>
<th>Station</th>
<th>Total Reactive Capital Work Requests</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>641</td>
<td>684</td>
<td>59</td>
<td>1,384</td>
</tr>
<tr>
<td>2014</td>
<td>885</td>
<td>636</td>
<td>15</td>
<td>1,536</td>
</tr>
<tr>
<td>2015</td>
<td>1,163</td>
<td>664</td>
<td>15</td>
<td>1,842</td>
</tr>
<tr>
<td>2016</td>
<td>1,142</td>
<td>430</td>
<td>50</td>
<td>1,622</td>
</tr>
<tr>
<td>2017</td>
<td>1,281</td>
<td>389</td>
<td>78</td>
<td>1,748</td>
</tr>
<tr>
<td>2018</td>
<td>1,517</td>
<td>286</td>
<td>72</td>
<td>1,875</td>
</tr>
<tr>
<td>Grand Total</td>
<td>6,629</td>
<td>3,089</td>
<td>289</td>
<td>10,007</td>
</tr>
</tbody>
</table>

b) Sub-categories of reactive capital work requests are provided in Table 1 above.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 65:

Reference(s): Exhibit 2B, Section E7.2

With respect to the proposed Grid Performance and Renewable Enabling Energy Storage System projects:

a) Please provide a copy of any internal business case for the projects.

b) [Appendix A] Has Toronto Hydro undertaken any cost/benefit analysis of its own regarding the proposed projects that quantifies the benefits using the methodology discussed in the 2010 EPRI report referenced or otherwise? If so, please provide details.

RESPONSE:

a) Toronto Hydro does not yet have business cases for Grid Performance ESS projects. As noted at page 13 of the program evidence, Toronto Hydro has not yet determined the suitable sites for these investments. Toronto Hydro expects to finalize site selection in 2020 to support installation starting in 2021.

Exhibit 2B, Section E7.2 identifies feeder 88M43 from Richview TS as a potential location for Grid Performance ESS due to its historically poor reliability. As outlined in ‘Option 2’ in E7.2.2.5 ‘Options Analysis’, to achieve the projected benefits of ESS for customers (eliminate voltage sags and momentary interruptions), there are two conventional ‘wires’ options:
1) **Placing lines underground:** Converting the existing overhead distribution of 88M43 to underground distribution would require a considerable amount of capital work, but would substantially reduce the frequency of momentary outages. To mitigate voltage sag events, feeders supplied by the same station bus as feeder 88M43 at Richview TS would need to be undergrounded as well. The Richview ‘Q’ station bus supplies three feeders total; a high-level estimate of converting three feeders would exceed $10 million, which is more than twice the estimated Grid Performance ESS spend.

2) **Building a new station:** Building a new station to supply these customers with new underground feeders would achieve the same benefits as Grid Performance ESS, however, the high-level estimate for a new station exceeds $30 million, which is far greater than the estimated Grid Performance ESS spend.

Using the example for feeder 88M43, this high-level business case demonstrates that the Grid Performance ESS solution is the most cost-effective.

For Renewable Enabling ESS, Toronto Hydro recognizes that energy storage may not always be the most economical option to mitigate generation to minimum load concerns, when compared to feeder re-configurations. However, ESS is able to provide stacked benefits, in addition to enabling renewable energy generation (REG). These benefits include the ability to use the ESS to supply load to a segment of a feeder during an outage, thereby improving reliability of supply. Furthermore, feeder re-configurations may not always be feasible due to the existing network configuration.

b) As detailed in this program’s evidence, and as briefly illustrated using a high level estimate example above, Toronto Hydro evaluates alternative solutions to satisfy its
legal obligations, address the needs of its customers, and manage the distribution system. These analyses weigh costs and benefits. Toronto Hydro’s Local Demand Response activities serve as an example of the targeted inclusion of ESS as such an alternative (refer to Exhibit 2B, Section 7.4.5.3 for details). The Local Demand Response initiative and the cost-benefit analysis behind it emerged from Toronto Hydro’s established asset management and optimization processes described in Exhibit 2B, Sections D1 and D3. As the costs of ESS technology continue to decline, ESS is increasingly a credible alternative to conventional ‘wires’ solutions.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 66:

Reference(s): Exhibit 2B, Section E7.3, p.11

Please add a column to Table 7 showing the estimated cost per project.

RESPONSE:

Table 7 of Exhibit 2B, Section E7.3 is reproduced below with a column added showing the estimated cost per project.¹

<table>
<thead>
<tr>
<th>Network</th>
<th>Total Load on Feeders (MVA)</th>
<th>Network Load (MVA)</th>
<th>Proposed Automation Year</th>
<th>Estimated Cost Per Project ($M) Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD Phase 1</td>
<td>49</td>
<td>11.6</td>
<td>2019</td>
<td>3.7</td>
</tr>
<tr>
<td>GD Phase 2</td>
<td></td>
<td>17.4</td>
<td>2020</td>
<td></td>
</tr>
<tr>
<td>CS-West Phase 1</td>
<td>45</td>
<td>11</td>
<td>2021</td>
<td>13.8</td>
</tr>
<tr>
<td>CS-West Phase 2</td>
<td></td>
<td>11</td>
<td>2021</td>
<td></td>
</tr>
<tr>
<td>Bridgman Total</td>
<td>29.2</td>
<td>14.6</td>
<td>2022</td>
<td>3.5</td>
</tr>
<tr>
<td>Highlevel Total</td>
<td>112</td>
<td>56</td>
<td>2022</td>
<td>12.2</td>
</tr>
<tr>
<td>Duplex Total</td>
<td>69.6</td>
<td>34.8</td>
<td>2023</td>
<td>7.5</td>
</tr>
<tr>
<td>Gerrard Total</td>
<td>12</td>
<td>6</td>
<td>2023</td>
<td>2.6</td>
</tr>
<tr>
<td>Dufferin Phase 1</td>
<td>5.5</td>
<td>4</td>
<td>2023</td>
<td>7.0</td>
</tr>
<tr>
<td>Dufferin Phase 2</td>
<td>15.7</td>
<td>12</td>
<td>2024</td>
<td></td>
</tr>
<tr>
<td>Glengrove Total</td>
<td>28</td>
<td>14</td>
<td>2024</td>
<td>2.7</td>
</tr>
<tr>
<td>Wiltshire Total</td>
<td>1</td>
<td>1</td>
<td>2024</td>
<td>0.4</td>
</tr>
</tbody>
</table>

¹ Project costs include inflation and engineering and administration costs.

Panel: Distribution System Capital and Maintenance
<table>
<thead>
<tr>
<th>Network</th>
<th>Total Load on Feeders (MVA)</th>
<th>Network Load (MVA)</th>
<th>Proposed Automation Year</th>
<th>Estimated Cost Per Project ($M) Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strachan Total</td>
<td>9</td>
<td>7</td>
<td>2024</td>
<td>1.7</td>
</tr>
<tr>
<td>Carlaw Total</td>
<td>9</td>
<td>7</td>
<td>2024</td>
<td>3.6</td>
</tr>
<tr>
<td>Main Total</td>
<td>9</td>
<td>7</td>
<td>2024</td>
<td>2.2</td>
</tr>
<tr>
<td>Leaside Total</td>
<td>3</td>
<td>2</td>
<td>2024</td>
<td>2.6</td>
</tr>
</tbody>
</table>
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 67:

Reference(s): Exhibit 2B, Section E7.4, p. 7

Please provide any internal business case that was created for the Copeland TS Phase 2 project.

RESPONSE:

Please refer to Exhibit 2B, Section 7.4.5.1 for a summary of the business case and the relevant options for Copeland Phase 2. Toronto Hydro does not have an additional internal business case for the project. Please note that Copeland TS Phase 2 was also included in the original business case for Copeland Phase 1. That business case was presented in EB-2012-0064 in Tab 4, Schedule B17, Appendices 2 and 3 and EB-2014-0116. In these business cases, the scope of work for Copeland TS Phase 1 included the construction of a civil structure (“Copeland building”) that would accommodate electrical equipment installed during both Phase 1 and Phase 2 of the project.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 68:

Reference(s): Exhibit 2B, Section E7.4, p.23

With respect to Copeland TS Phase 1:

a) Please provide full details regarding the $15.1M increase in the cost as compared to what was included in the EB-2016-0114 budget.

b) Please provide a copy of the original internal business case for the project and any revised business cases that were subsequently developed for the project.

c) Please provide a copy of the risk registrar developed for the project.

d) Please provide copies of any post-competition/lesson-learned or similar report that was completed. If one was not completed, please explain why not.

e) Please explain what lessons Toronto Hydro has learned regarding Phase 1 that it is using for the purposes of planning Phase 2.

RESPONSE:

a) Please refer to Toronto Hydro’s response to interrogatory 2B-Staff-95 (c).

b) Please refer to EB-2012-0064 (2012-2014 ICM Application), Tab 4, Schedule B17 Appendices 2 and 3 for the original Copeland TS Phase 1 business case.
Progress on Copeland TS Phase 1 was reported in EB-2014-0116, Decision and Order (December 29, 2015).

c) Toronto Hydro utilized internal Enterprise Risk Management (ERM) tools to perform risk assessment on the Copeland project. The latest risk matrix for Copeland TS Phase 1 is attached – refer to Appendix A.

d) As Copeland TS Phase 1 is not yet complete, Toronto Hydro continues to review and compile lessons learned.

e) Lessons learned from Copeland TS Phase 1 is an integral part of planning and executing Copeland TS Phase 2. Phase 2 is a continuation of Phase 1, and thus have many similar tasks. Toronto Hydro is able to capitalize on the actions taken in Phase 1 project to determine what problems occurred, how those problems were handled and they may be avoided in the future. As noted in response to (d) above, Toronto Hydro is still compiling lessons learned from Phase 1 and incorporating these into Phase 2.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 69:
Reference(s): Exhibit 2B, Section E8.1

Please provide any internal business case that was created for the Control Operations Reinforcement program.

RESPONSE:
An internal business case setting out the preliminary general scoping of the Control Operations Reinforcement program is attached as Appendix A to this response. Please note that parts of the document have been redacted for confidentiality purposes.

Please also refer to the evidence in Exhibit 2B, Section E8.1, which provides the main elements of Toronto Hydro’s business case for this program, including the following: the drivers of the investment, the costs, the options analysis, and the proposed approach.
HONI Schedule (E) – Probability Virtually Certain: HONI encountered failures with some of their circuit breakers and is fixing issue – Issue escalated to HONI EVP and COO. Only one circuit expected to be completed by Dec 3, Remainder of interrupters were delivered, the other circuit is projected for March 2019.

IBI Design Changes and Staffing (G) – Probability reduced to Unlikely: IBI completed final sign-off documentation of the electrical design and execution in November; civil/structural work remains.

City Lane Closures and Road Restrictions (I) & Permits (K) – Probability Remote, Consequence decreased to Minor: City permitting and other restrictions will not impact remaining work.

Construction Errors/Quality (J) – No Change: Risk of Carillion not remediating all outstanding deficiencies. Mitigation: Utilize Surety to complete work (may cause delay) or TH funds remediation work without Surety approval ahead of time with resultant cost risk.

Dispute Resolution (C) & Carillion Change Order/Delay Costs (B) – OPEX Budget approved for accelerated legal expenses in 2018. Claims process underway. TH has submitted its claim to the court and draft claims consultant report on Carillion’s claim received. Minimal impact on site and energization activities.
Preliminary Scoping Business Case – Control Operations Reinforcement Program
# Table of Contents

1 EXECUTIVE SUMMARY ................................................................. 3

2 PROBLEM STATEMENT ................................................................. 3
   2.1 Problem Statement .................................................................. 5
   2.2 Business Requirements .......................................................... 8
   2.3 Assumptions & Dependencies ................................................... 10

3 PROPOSAL DESCRIPTION ............................................................ 10
   3.1 Proposed Solution Description .................................................. 10
   3.2 Options Analysis .................................................................... 11
   3.3 Solution Scope & Cost ............................................................. 12
   3.4 Benefits & Outcomes ............................................................... 14
1 EXECUTIVE SUMMARY

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Costs</th>
<th>Duration (In months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Control Centre</td>
<td>$40.2M</td>
<td>~36</td>
</tr>
</tbody>
</table>

Toronto Hydro’s Distribution Grid Operations team provides critical Control Centre and Dispatch services to all field & customer operation functions within the organization using specialized systems and tools located at the current 500 Commissioners Street Control Centre. A disruption to these services due to a short or long-term displacement from the 500 Commissioners Street facility will significantly impact the ability of Toronto Hydro to deliver on core business objectives and meet the basic expectations of customers, stakeholders and third party organizations (i.e. HONI, IESO, TTC, Metrolinx etc.). While the probability of such a scenario occurring is low, it is still plausible and the magnitude of the impact would be severe.

In order to mitigate this significant risk, Toronto Hydro is proposing to construct a fully redundant, dual Control Centre within the

2 PROBLEM STATEMENT

The Control Centre is the control authority for Toronto Hydro and the real-time operator of the distribution system. From the Control Centre at 500 Commissioners, department staff coordinates and monitors the distribution of electricity across Toronto Hydro service territory.

The Control Centre has two primary responsibilities:

a) To maintain real-time monitoring and control of THESL’s distribution plant; and

b) To coordinate all activities involving workers within the “safe limits of approach” to THESL plant that is energized above 750 Volts.

The portion of THESL’s distribution plant under the direct control of the Control Authority includes all intermediate-voltage equipment and cabling normally energized at 4 kV, 13.8 kV, or 27.6 kV. This real-time control includes the monitoring of grid operation, system loading, and the response to system or asset failures. Operating a complex grid in a dense urban environment with unique system designs (e.g. secondary mesh network, underground radial distribution, compact radial distribution, dual radial, etc.), volume of emergencies and power-outage related response needs, volume of capital/maintenance work and sustained workforce renewal needs all contribute to the critical need for a continuously available and functional operations centre. The control centre is key to supporting various priority services within the City of Toronto, which include Emergency services (Police, Fire and Ambulance), telecommunication facilities, hospitals, Water & Wastewater infrastructure, financial sector etc.
2.1 Problem Statement

In the current state, Toronto Hydro only has one facility at 500 Commissioners street that is capable of enabling the Control Centre and Dispatch departments to execute their full scope of business processes at the scale required for day-to-day operations.

Over the last five years, Toronto Hydro’s operations have been disrupted by several large-scale environmental and other hazard events. These large scale environmental and hazard events are becoming increasingly more common within Toronto Hydro’s service territory and across the industry. Recently, Toronto Hydro has experienced a number of severe weather-related events that caused wide-spread damage and outages. Further, in addition to more frequent and severe weather events, there continues to be an escalation of the probability of terrorist activity causing damage to people and property, cyber terrorist attacks, as well as system attacks from increasingly sophisticated hackers. Public Safety Canada issued a report titled “The 2017 Public Report on The Terrorist Threat to Canada” indicating that since 2014, Canada’s terrorism threat level is Medium, meaning that a violent act of terrorism could occur.

1. **Risk of a full long-term displacement from 500 Commissioners Control Centre facility:**
   - Long-term displacement from the existing main Control Centre is unlikely, but plausible
   - There are a number of hazards and threats that could result in this outcome, including:
     - Regional flooding
       - Localized or regional flooding that causes flooding conditions within the flood plain that the existing Control Centre occupies. This flooding could cause primary damage to electrical, mechanical or other systems. The flooding could also cause secondary damage to areas in which water infiltrated. This damage can impact access to the facility and could include mold and other contamination which requires substantial remediation before occupancy can resume.
     - Fire or explosion
       - A fire or explosion (either accidental or intentional) that causes primary damage to the C&C facilities and triggers sprinklers to activate and flood the C&C facility or the systems that support the C&C facility.
     - Tornado
       - Tornadoes are rare for the GTA. However, if a powerful tornado were to strike either site, it is conceivable that occupancy would be limited until structural repairs were made.
     - Deliberate threat
       - Physical or cyber-attack by a third party targeting electricity infrastructure in Canada’s largest city and regional economic hub.
     - Other threats
       - Nuclear or chemical spills.
2. **Component**

<table>
<thead>
<tr>
<th>Component</th>
<th>Main Control Centre</th>
<th>Back-Up</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

- **500 Commissioners Standard Operating Desk**

- **500 Commissioners Street Layout**
As a result, a long-term displacement from 500 Commissioners would have catastrophic impacts on Toronto Hydro’s operations and significantly compromise the level of service provided to customers.

2.2 Business Requirements

In order to adequately address the challenges described above, a fully redundant dual Control Centre is required. Detailed requirements are as follows:

- Facility to be located in a geographically diverse location relative to 500 Commissioners Street so as to minimize exposure to common mode environment hazards and threats.
- Designed to accommodate a full shift complement of Power System Controllers, Dispatchers, Supervisors and critical support staff.
- Capability to operate in parallel with existing Control Centre and seamlessly transfer operations between facilities
- Designed for 24/7/365 operation
• Access to all Control Centre systems with appropriate end-user hardware and software, including:
  o Accommodation of standard workstations for Power System Controllers, Dispatchers and support staff
  o Compliance with all relevant building codes and standards.
  o Layout shall be designed to optimize operational efficiency
  o Audio/visual requirements shall include:
    o LCD TVs shall be provided to compliment the SCADA monitors
    o Additional LCD screens shall be supplied and installed for corporate communications and cable TV transmission. The screens shall be controlled via a Crestron control system
    o Monitor mounting and arrangements shall optimize workstation footprint requirements with the company's ergonomic standards
  o Lighting and ambient noise control requirements:
    o Each area is subject to be exposed to noise from phone systems, radio traffic and/or alarm notification systems. The acoustics of the room therefore shall be designed to have adequate active noise cancellation and passive noise suppression features
    o Dimmable ceiling mounted spot lighting controls
  o Telecommunications requirements include:
2.3 Assumptions & Dependencies

The following assumptions have been made regarding to the overall scope of this project:

- The final operating model post construction of the dual facility will not require a material increase in Control Centre staffing;
- Detailed design and construction work will commence after receiving a favourable decision from the OEB on the 2020-24 CIR application which is assumed to occur by December 31, 2019; and
- Any change in this understanding will result in a change to the project scope and will be subject to the established change process.

3 PROPOSAL DESCRIPTION

3.1 Proposed Solution Description

Toronto Hydro is proposing to build a fully redundant, dual Control Centre in undeveloped but allocated space at the work centre. The dual Control Center provides Toronto Hydro with the necessary and adequate functionality, similar to the existing Control Center, to address its current and future needs.

Construction of the Control Centre will be managed by the Facilities Department at Toronto Hydro with the support of the Operations team. The Facilities Department has experience and can utilize the appropriate tools to manage the project with the necessary rigor to ensure value for money. Some of the benefits of utilizing the Facilities Department include:
- Experience gained from constructing the primary Control Centre at 500 Commissioners and
- Experience with Control Centre construction (redundant power, NERC standards, specialized needs, etc.)

Similar to OCCP, a design team (consisting of Architectural, Electrical, Mechanical, Security and Structural consultants), project managers, contract administrators and construction managers will be utilized to help oversee and deliver this project for Toronto Hydro.
### 3.2 Options Analysis

The following options have been considered:

1. Status quo / do nothing
2. Fortification of 500 Commissioners Street to reduce probability of long-term displacement
3. Construction of fully redundant dual Control Centre at [insert location]
4. Construction of fully redundant dual Control Centre at [insert location]
5. Construction of fully redundant dual Control Centre at [insert location]
6. Construction of limited footprint dual Control Centre at [insert location]
7. Construction of fully redundant dual Control Centre at a new facility

Each option was evaluated based on the following criteria:

a) Current-state risks associated with proposed location (e.g. is the proposed location within the path of a flood plain?)
b) Available space within the proposed location (when compared to minimum space requirements for an dual Control Centre)
c) Existing technological capabilities within the proposed location (when compared to minimum technological requirements for an dual Control Centre)
d) Enablement for a fully-staffed dual Control Centre within the proposed location (in contrast to enablement of a backup Control Centre)
e) Impact associated with a terrorist event, and whether the event would prevent the full enablement of the dual Control Centre
f) Total estimated costs to construct the dual Control Centre at the proposed location

See below for a high level summary of the detailed option evaluation.

<table>
<thead>
<tr>
<th>Criteria / Location</th>
<th>New Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather Risks</td>
<td></td>
</tr>
<tr>
<td>Available Space</td>
<td></td>
</tr>
<tr>
<td>Existing Technological Capabilities</td>
<td></td>
</tr>
<tr>
<td>Dual Control Centre Enablement</td>
<td></td>
</tr>
<tr>
<td>Impact of Terrorism Attack</td>
<td></td>
</tr>
<tr>
<td>Total Estimated Costs</td>
<td>Red</td>
</tr>
</tbody>
</table>

**Legend**

- Does not meet criteria
- Partially meets criteria
- Meets or Exceeds Criteria
3.3 Solution Scope & Cost

Based on the analysis in section 3.2 Toronto Hydro is proposing to pursue the option of building a fully functional dual Control Centre at [location], pending OEB approval.

This project involves:

- Interior renovations/alterations to accommodate a new Control Centre that meets the requirements described in Section 2.2 of this document.
- Alterations to an area on the ground floor to accommodate a new Control Centre and associated Electrical, Mechanical and IT support spaces.
- Construction of a new Second Floor for Control Centre operational support functions.
- Alteration of the existing parking lot to the east side of the building to allow for upgrades to existing conditions.
- Installation of dual generators and dual UPS’ (Uninterruptable Power Supplies).

Soft cost expenditure is forecasted to commence in 2020 with consultant fees for feasibility cost planning, design, and permitting. The consulting team will produce a detailed drawing package for the build out of the dual Control Centre. They will participate in progressive client design review meetings to finalize details and ensure operational efficiency. Once deliverables are finalized, the consulting team will manage the building permit application process and any Preliminary Project Reviews or Site Plan approval applications with the City of Toronto. A team of experienced project managers working under the direction of the Facilities department will be contracted to manage the construction of the dual Control Centre from inception to completion. They will bring expertise in knowledge of construction administration, construction law (CCDC) and payment certifications. Once construction begins, the project management and consulting team will be active throughout all construction phases to perform regular construction inspections, shop drawing reviews and approvals, payment certifications, participate in construction meetings, and overall construction support. The soft cost expenditure plan will conclude in 2022 with closeout document preparations, deficiency reviews, and asset testing and commissioning.

The alterations and demolition expenditure plan will occur in the early phases of construction and will include removal of existing concrete footings and structural steel in preparation for the build out of the second floor. In order to accommodate the installation of large equipment during building construction, the concrete exterior wall will be demolished and replaced with modular louvered wall system. Existing mechanical, electrical infrastructure will also be removed in preparation for new installations.

The majority of the costs in the expenditure plan are for building construction. Architectural plans will be constructed with provisions for the second floor build out, separate mechanical, electrical and IT hub rooms. These provisions will be formed by two story masonry block walls, concrete foundations, interior wall finishes, and structural steel. Mechanical and electrical equipment will be purchased and installed once architectural components have sufficiently progressed. The mechanical equipment is comprised of HVAC systems used to heat and cool office spaces, plumbing for washroom facilities, air extraction for generator equipment, cooling capacity for IT and UPS rooms, and fire sprinkler systems. The electrical building cost expenditure is a large portion of the building construction costs due to the dual generators and dual UPSs (Uninterruptible Power Supply) that will be installed as per Control Centre requirements based on TIER 1 utility, TIER 2 generator, TIER 3 UPS and TIER 3 EPS and UPS distribution. As the project progresses into the final years of construction, interior finishes will be installed in the office spaces such as ceiling tiles, carpet, tiling, office furniture, audio visual equipment and IT hardware.

The expenditure plan for site works will begin once a site plan approval has been granted for the expansion of the staff parking lot. This will include new asphalt, walkways, curbs and modification to the storm water management system. Due to site conditions, a retaining wall will be constructed to allow for additional parking spots. Also included in the site works expenditure plan are new light standards and
security equipment. This equipment will ensure that the parking lot is appropriately lit during dark hours and our employees are safe coming to and leaving the facility.

All of the above details surrounding the expenditure plan for the alternate Control Centre comes with potential additional costs due to the construction work occurring in an occupied work centre. Considerations for noise and disruption will have to be taken into account when scheduling construction work. This could result in after-hours work, fire panel bypass, fire watch and contingencies to maintain business continuity. Contingencies for these items have been included in the construction estimate. See below for a summary of costs.

<table>
<thead>
<tr>
<th>Category</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Costs ($M)</td>
<td>3.4</td>
<td>2.6</td>
<td>4.8</td>
<td>10.8</td>
</tr>
<tr>
<td>Alterations and Demolitions ($M)</td>
<td>-</td>
<td>14.1</td>
<td>11.8</td>
<td>25.9</td>
</tr>
<tr>
<td>Building ($M)</td>
<td>-</td>
<td>0.3</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Site-works ($M)</td>
<td>0.5</td>
<td>0.4</td>
<td>1.7</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Total ($M)</strong></td>
<td><strong>3.9</strong></td>
<td><strong>17.4</strong></td>
<td><strong>18.9</strong></td>
<td><strong>40.2</strong></td>
</tr>
</tbody>
</table>

Implementation of this solution is forecasted to result in relatively minor incremental OM&A. No material increases in Control Centre staffing are planned to specifically support a dual Control Centre operating model. Minor cost increased will be incurred for utility costs and IT hardware/software. See below for a summary.

<table>
<thead>
<tr>
<th>Category</th>
<th>Forecasted Annual OM&amp;A Increase ($k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities (utilities and maintenance)</td>
<td>$150</td>
</tr>
<tr>
<td>IT Hardware and Software Licenses</td>
<td>$200</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$350</strong></td>
</tr>
</tbody>
</table>

A potential project organizational structure is presented below:

A tentative project schedule is provided below.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Timeline</th>
</tr>
</thead>
</table>

Toronto Hydro Electric System Ltd. 13
<table>
<thead>
<tr>
<th>Design</th>
<th>Develop and procure contracts for construction manager, project management and contract administrator</th>
<th>Q2 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete the design tender drawings</td>
<td>Q2 2020</td>
</tr>
<tr>
<td></td>
<td>Begin obtaining City approvals in order to proceed with construction (site plan approval, permits, etc.)</td>
<td>Q2 2020</td>
</tr>
<tr>
<td></td>
<td>Review and approve design drawing for the Control Centre</td>
<td>Q3 2020</td>
</tr>
<tr>
<td></td>
<td><strong>Construction</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once drawing are ready for tender, work with the team to develop project schedule and critical path</td>
<td>Q3 2020</td>
</tr>
<tr>
<td></td>
<td>Tender the construction work</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Begin construction at [ ] and ensure adherence to the project schedule.</td>
<td>Q4 2020</td>
</tr>
<tr>
<td></td>
<td>Procure Furniture / Equipment for Office Space</td>
<td>Q4 2022</td>
</tr>
<tr>
<td></td>
<td>[ ] Dual Control Centre’s substantial completion</td>
<td>Q4 2022</td>
</tr>
<tr>
<td></td>
<td><strong>Commissioning</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work with team to identify and address all construction deficiencies</td>
<td>Q4 2022</td>
</tr>
<tr>
<td></td>
<td>Create and deliver close out documentation to Toronto Hydro</td>
<td>Q4 2022</td>
</tr>
<tr>
<td></td>
<td>“Go Live” with Control Centre</td>
<td>Q4 2022</td>
</tr>
</tbody>
</table>

### 3.4 Benefits & Outcomes

Construction of a fully redundant dual Control Centre at [ ] will increase Toronto Hydro’s operational resiliency and improve the utility’s ability to safely operate the distribution grid. The dual Control Centre at Toronto Hydro will be designed to withstand the above mentioned physical hazards and cyber threats, deliver reliable electricity, and support the capability to restore electricity as efficiently as possible. This project will aim towards the following corporate outcomes:

#### Reliability
- Contributes to Toronto Hydro’s reliability objectives (e.g. SAIDI, SAIFI, FESI-7)

#### Safety
- Contributes to Toronto Hydro’s safety objectives as measured by Total Recordable Injury Frequency ("TRIF")
- Response to Emergency Services (Police, Fire and Ambulance)
- Public Safety incidents (i.e. Wires down)

#### Customer Service
- Contributes to Toronto Hydro’s customer service objectives (i.e. connections and customer initiated isolations)

#### Public Policy
- Consistently meeting OEB-mandated service quality targets with respect to Emergency Response (Distribution System Code, s. 7.9).
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 70:
Reference(s): Exhibit 2B, Section E.8.4, p. 18

Please provide any internal business case that was created for the ERP and CIS upgrades.

RESPONSE:
Internal business cases setting out the preliminary general scoping of the Enterprise Resource Planning and Customer Information System upgrades are attached as Appendices A and B, respectively, to this response.

Please also refer to the evidence in Exhibit 2B, Section E.8.4, which provides the main elements of Toronto Hydro’s business case for these upgrades, including the following: the drivers of the investment, the costs, the options analysis, and the proposed approach.
Preliminary Scoping Business Case – Enterprise Resource Planning ("ERP")
# Table of Contents

Table of Contents ................................................................. 2

## EXECUTIVE SUMMARY ....................................................... 4

## PROBLEM / OPPORTUNITY STATEMENT .................................. 4

  2.1 Problem / Opportunity Statement ........................................ 4
  2.1.1 Critical Information Technology Infrastructure Assets .................... 4
  2.1.2 Product Life Cycle of ERP Software ......................................... 5
  2.1.3 Strategy To Stay Current With Tier 1 Applications .......................... 6
  2.2 Business Requirements ...................................................... 7
  2.2.1 High-Level Sustainability Requirements ...................................... 8
  2.2.2 High-Level Functional Requirements ......................................... 8
  2.3 Assumptions & Dependencies ................................................ 10

## PROPOSAL DESCRIPTION ....................................................... 10

  3.1 Proposed Solution Description ............................................ 10
  3.2 Solution Scope .................................................................. 12
  3.3 Options Analysis .................................................................. 13
  3.4 Cost ................................................................................ 14
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Document Objectives

The purpose of this document is to provide a common template that will be used for projects within the Toronto Hydro organization, initiated to remain in compliance with Toronto Hydro IT standards.
1 EXECUTIVE SUMMARY

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP 2020-2014 Rate Period</td>
<td>$46.3M</td>
</tr>
</tbody>
</table>

SAP, SuccessFactors and Ariba systems (collectively ERP system) implemented as part of the Enterprise Resource Planning 2015-2019 program (ERP 2015-2019 Rate Period program) is a foundational platform that has significant capabilities with respect to adding new functional capabilities, new reporting features and integrating with major existing non-ERP systems. Through the ERP 2020-2024 Rate Period program, Toronto Hydro seeks to enhance the existing ERP system which support core business processes and operations. This program will also look at and migrate to ERP any systems that have reached their end of life or identify and migrate those services and functionalities that can be better provided through an upgraded ERP system.

Finally, the ERP 2020-2024 Rate Period program’s objective is to maintain, operate and develop the ERP system in line with Toronto Hydro’s Asset Management Life Cycle Methodology, Run-Grow-Transform\(^1\) strategy and adhere to Toronto Hydro’s IT Architectural Standards.

The intended benefits of this program are to:

- increase efficiency through a modern, secure, robust, well-supported and consolidated ERP system;
- integrate with other non-ERP systems to increased system reliability, eliminate duplication and reduce manual efforts;
- improve data governance and data management through the integrated ERP system;
- improve quality of management reporting and strengthen the decision making process;
- customer service employees will be able to better serve the customer through integrated access to customer information/work orders; and
- field workers will be able to have increased access to the systems and get information and data in the field and thereby improve business operations and efficiency.

2 PROBLEM / OPPORTUNITY STATEMENT

2.1 Problem / Opportunity Statement

2.1.1 Critical Information Technology Infrastructure Assets

As Toronto Hydro evolves, regular and planned capital investment would be required to its IT systems to keep it current, reliable and secure. Similar to how physical assets age, IT technology matures over time, business needs change and new cyber security threats emerge.

The ERP system is a Tier 1 application\(^2\). It is critical to maintain currency for Tier 1 applications. Toronto Hydro has been following the prudent practice of maintaining currency, not necessarily at the

\(^1\) Based on Gartner’s Run-Grow-Transform Framework

\(^2\) IT Software Standards classify software applications in two categories – Tier 1 and Tier 2 – based on the consideration of the operational criticality of the application, level of complexity, integration with other applications, maintenance costs and number of...
leading edge of technology, but rather a version which is well tested and adopted by the industry. This practice ensures the best value for money as well as a product/version that has been tested in the market, is widely accepted as well as free from bugs and faults. This is the version where the vendor has responded to and tackled most customer issues. Hence, installing a version at least one version behind the latest version generally has the highest level of quality in terms of RASM\(^3\).

SAP BW is the business information warehouse that ERP at Toronto Hydro uses. The current equivalent technology is SAP HANA that includes a database and which has been in the market since 2011. Similarly, SAP ECC 6.0 EHP 8.0 is the ERP application at Toronto Hydro. The current equivalent technology is SAP S/4 HANA which has been in the market since 2015.

The figure below illustrates the market timing of SAP products. Now, as part of the 2020-2024 rate period, is the appropriate time to upgrade both the database and application.

![Figure 1: Market Timing of SAP Products](image)

Source: Illustration adapted from erpinnews.com

### 2.1.2 Product Life Cycle of ERP Software

Our current vendor, SAP, is a global giant in enterprise resource planning software and has strong history of continuous development of new products through innovation. SAP, realizing the criticality of the ERP applications, follows an Innovative Maturity Model for the development of its product (product life cycle). In this model before a product reaches the end of its life it is significantly enhanced through innovative features and technology to be able to continue on another wave of sales and/or implementation. This approach is further promoted by acquisition of other companies’ products and integrating it with their core product. This continually expands the functional coverage of an ERP system across the company’s operations and business. This model of product development is illustrated in figure below.

---

3 RASM – Reliability, Availability, Security and Manageability. An industry term for when a software has reached stability in use, adoption and realization of benefits from the product.
2.1.3 Strategy To Stay Current With Tier 1 Applications

Toronto Hydro’s strategy is continuous upkeep by carrying out technical and functional upgrades. The figure below highlights the benefits of this strategy to keep Tier 1 applications, like the ERP system, current. The investment amount in any particular year and the initiatives depend on the product strategy of the vendor and the vendor’s support to its clients. It also depends on new tools and business solutions that the vendor may develop in the future as well as the cost and benefits of such solutions to Toronto Hydro.

Regular, planned and evenly paced investment in ERP
- Smaller annual amounts
- Currency achieved
- Easier to manage
- Continuous improvement
- Gradual org change management
- Easily managed implementation
- Shorter implementation period – adopt emerging technologies
- Value for money from the perspective of effectiveness

Based on the above and anticipated business and IT needs of Toronto Hydro the initiatives in the ERP 2020-2024 Rate Period program are divided as Sustainment stream initiatives and Enhancement stream initiatives.

Sustainment stream initiatives – SAP releases notes/patches on predetermined schedule for various SAP components. These updates to underlying infrastructure need to be performed to maintain stability and patch linkages.
The Enhancement stream initiatives are further grouped into five categories as Integration, Reporting Capability, Advanced Functionality, Ariba and SuccessFactors initiatives. The figure below illustrates at a high level the program and how it relates to the existing ERP system.

**Proposed focus areas for the program**

![Diagram showing proposed focus areas for the program]

Figure 3: Preliminary Illustration Of ERP 2020-2024 Rate Period program focus areas

The initiatives planned for ERP 2020-2024 Rate Period contains the following focus areas:

- **Sustainment** – notes/patches, updates, migrations, upgrades; SAP HANA database; and SAP Business Suite 4 SAP HANA (or SAP S/4HANA) application.
- **Integration with non-ERP legacy systems** – initiatives that integrate ERP with other major (non-SAP) IT systems such as OpenText Document Management System (DMS); Customer Care & Billing (CC&B); Network Management System (NMS); Mobile Workforce Management (MWM); and Geographical Information System (GIS).
- **Reporting Capability** – initiatives that enable reporting and analytics capabilities through initiatives such as SAP Business Warehouse (BW); and SAP Business Objects (BOBJ).
- **Advanced Functionality** – initiatives that enable new functionality in SAP such as Linear Asset Management (LAM); Warehouse Management System (WMS); Vendor Electronic Enablement; Environment, Health & Safety (EH&S); Governance Risk & Compliance (GRC); and Vendor Invoice Management (VIM).
- **Ariba** – Supplier Performance Management; and Vendor Electronic Enablement.
- **SuccessFactors** – SuccessFactors maturity and further integration of the modules to the SAP ECC system.

### 2.2 Business Requirements

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4 HANA – High-Performance Analytic Appliance, an SAP product
An implied objective of any ERP optimization and consolidation is the further alignment of business processes to day-to-day activities. Nonetheless, the directly related objectives of this program are to:

- Enhance the foundational platform that the current ERP created through integration with corporate non-ERP systems for more seamless processes and associated improved productivity (increase employee efficiency, eliminate duplication and reduce manual efforts)
- Achieve new functionality in ERP through a modern, secure, robust and well-supported centralized system
- Improve quality of financial reporting and strengthen the decision making process

Allow secure, reliable and sustained use of the ERP system for the entire duration of its life.

The key, high-level business requirements\(^{5}\) to ensure sustainability, reliability and deliver business objectives are outlined as sustainability requirements and functional requirements in the following two tables:

### 2.2.1 High-Level Sustainability Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor Supported Solution(s)</td>
<td>Maintaining vendor provided General Support for each application, database or development technology is key to sustainable information technology solutions, for it enables Toronto Hydro’s Information Technology Division to provide its users with secure, functionally rich and reliable applications without employing the staff that would be required to design, test, implement and maintain each solution.</td>
</tr>
<tr>
<td>Vendor Stability</td>
<td>Given that Toronto Hydro is relying upon its application, database and development technology vendor to enable it to provide its users with up-to-date, secure and reliable applications, the stability and strength of its vendor is an important sustainability factor. A financially strong vendor with an established industry presence and a clear application roadmap will, over time, build functionally rich solution offerings which, in turn, will reduce the need for Toronto Hydro to implement new applications to fulfill new business solution requirements.</td>
</tr>
<tr>
<td>Ease of Technical Administration and Support</td>
<td>To help ensure that its Information Technology Division remains as modest in size as possible while, at the same time, continuing to enable necessary business functions, the degree to which the solution facilitates technical administration is important. In addition, the availability of application support, from both vendor and system integrator – where required, is an important factor to consider, as it lowers implementation costs and speeds time to result.</td>
</tr>
</tbody>
</table>

### 2.2.2 High-Level Functional Requirements

To address the business and operations requirements, the new solution will maintain the functionality currently provided by the existing ERP system as well as deliver the following incremental capabilities:

---

\(^{5}\) Note that these are high-level requirements only and are intended to be used as a guide to the future option selection process. While directionally correct, they will be augmented and expanded upon in Sustainability and Functional Requirement Specifications should the project receive funding and proceed to the next stage.
<table>
<thead>
<tr>
<th>Categories</th>
<th>Incremental Solution Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Typically every year, based on predefined schedule (schedule outlook is typically 6 months), SAP releases OSS notes / patches to various SAP components. The updates to underlying infrastructure need to be performed in conjunction to maintain stability and patch linkages. Scope - Perform a technical upgrade only.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Upgrade to SAP HANA - We have implemented SAP ECC 6.0 EHP 8.0; SAP will release the roadmap for SAP ECC – third party databases in Jan 2019. Depending on the future roadmap upgrading our SAP ECC to run on HANA may have to be eventually considered. Scope - Upgrade BI and ECC to SAP HANA.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Data Archiving / Decommissioning Program - Initiative to ensure that we decommission 35 applications and enable an archiving solution. Scope - Maintain high frequency legacy for read only to account for as needed data retrieval and retire low frequency legacy (store cleansed low frequency data in BI).</strong></td>
</tr>
<tr>
<td>Sustainment Stream</td>
<td><strong>Integration with Open Text to bring in cross functional process based workflows, notifications and meta-data to flow back and forth between the two systems. E.g., Integration of GCF, RCF, WCF process and process for storage and integration of picture storage for construction and inspection work. Scope - Legal and financial attachment types supported only.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Integration with CC&amp;B to bring in metering orders and tie them to work orders, this will also include CAF process. Scope - One to one mapping between MO and WO supported with 2 way integration.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>The extent of Integration with NMS and Oracle MWM will depend on the scope of Oracle MWM project and details of work being performed in NMS vs. Oracle MWM. Scope - One to one mapping between NMS/Oracle MWP and SAP supported with 2 way integration.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Integration with GIS to sync equipment and asset registries between two systems. The complexity depends on the choice of the solution. Scope - One to one mapping between GIS and SAP supported with 2 way integration.</strong></td>
</tr>
<tr>
<td>Enhancement Stream</td>
<td><strong>Enablement of Netezza and SAP BW has been enabled through the foundational program however extending Netezza to satisfy all business esp. future regulatory requirements will happen over longer period of time. Scope - Carry over historical data up to two years back for regulatory related reporting only and maintain legacy for older data retrieval.</strong></td>
</tr>
<tr>
<td>Integration</td>
<td><strong>Regulatory - Models and reports for regulatory team to support OEB Application; includes SAP BW and self-serve reporting. Scope - Export structured data into BW and train staff on self-serve reporting using &quot;variants&quot; (Requires BW/BI in house skills in both IT and the business).</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Enabling asset analytics interface with SAP BW and calculations in Business Objects (BOBJ) space. Scope - Extract SAP EAM data into structured BW/BI cubes to be used as data feeds into a 3rd party Asset Analytics application.</strong></td>
</tr>
<tr>
<td>Enhancement Stream</td>
<td><strong>Enabling scope of linear asset management in SAP ECC will depend on creation of nomenclature in GIS and DMS to manage linear assets. This may also include updates to SAP accounting ledgers to accommodate the changes to accounting treatment of assets. Scope - Implement LAM and incorporate all linear assets through data conversion.</strong></td>
</tr>
<tr>
<td>Advanced Functionality</td>
<td><strong>Bring Red Prairie (Warehouse Management System) within SAP. Scope - Perform a technical and functional upgrade and perform limited functional enhancements.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Enable EDI interface through Ariba / Value Added Network (VAN) to ensure all the TH vendors are EDI enabled. Scope - Account for vendor collaboration via Ariba and VAN (hybrid).</strong></td>
</tr>
</tbody>
</table>

---

6 Only incremental requirements are detailed here. A full list of functional requirements will emerge from the SIPOCs and will be included in any RFI / RFP.

Toronto Hydro Electric System Ltd.


<table>
<thead>
<tr>
<th>Enhancement Stream – Ariba</th>
<th>• Configuration of other modules within Strategic Sourcing Ariba Suite - Supplier performance management; adding digital signatures for approvals and documentation. Scope - Configure other modules limited to SAP data feeds and vendor collaboration enablement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancement Stream – SuccessFactors</td>
<td>• Enabling and maturing more seamless data flow across different SuccessFactors modules and between SF and ECC. Enabling fully integrated end to end solution and business processes through enhanced integration between SuccessFactors and SAP ECC.</td>
</tr>
</tbody>
</table>

2.3 Assumptions & Dependencies

The following assumptions have been made related to the overall scope of this project:

- Successful Go-live of ERP 2015-2019 Rate Period program on October 1, 2018.

3 PROPOSAL DESCRIPTION

3.1 Proposed Solution Description

As described earlier, this program is composed of the following streams:

- Sustainment stream initiatives – these are initiatives that are typically required to update, maintain and upgrade the core ERP system with no or minimal new functionality or capability.

Typically every year, based on a predefined schedule (schedule outlook is usually 6 months), SAP releases OSS\(^7\) notes / patches to various SAP components. The updates to underlying infrastructure need to be performed to maintain stability and patch linkages and this will be ongoing throughout the 2020-2024 rate period. Also part of these initiatives would be the upgrading of the existing ERP database and application software to a more current version. The upgraded version of ERP has been in the market for more than three years and Toronto Hydro believes it is now time to install this version. While support for the current version of SAP (ECC 6.0 EHP 8.0)\(^8\) will likely be available till 2025 (as covered through SAP roadmap released in January 2018 and is subject to change in subsequent SAP releases), development of new functionality and features for this version of SAP has effectively stopped as a newer version of the software has already been rolled out by the vendor. This newer version is HANA for the database and SAP Business Suite 4 SAP HANA\(^9\) (or SAP S/4 HANA) for the application.

One of the initiatives is to enable an archiving solution for the approximately 35 legacy systems that would need to be decommissioned following the ERP 2015-2019 Rate Period program. The data

\(^7\) OSS – Operational Support System

\(^8\) ECC – ERP Central Core; EHP – Enhancement Packages

\(^9\) SAP S/4 HANA is SAP’s next generation business suite (application). It’s meant to replace SAP ECC/ERP with a simplified tool designed specifically to work with HANA database.
archiving and decommissioning program would maintain high frequency legacy as-needed data retrieval and retire low frequency legacy data.

- Enhancement stream initiatives – These are initiatives that bring additional benefits of productivity, efficiency, ease of doing business and improved customer service.

Integration with other non-ERP systems – Integrate with other non-ERP systems to increase employee efficiency, eliminate duplication and reduce manual efforts. These initiatives integrate ERP with systems such as OpenText; Customer Care & Billing (CC&B); Network Management System (NMS); Mobile Workforce Management (MWM); Geographical Information System (GIS) and Time Sheet application. This integration will allow for faster transfer of information and data as well as reduced manual intervention which decrease the risk of errors and omissions.

Reporting capability – These initiatives improve quality of management reporting and strengthen the decision making process related to plant investment. These initiatives enable reporting, data archiving and analytics capabilities through initiatives such as SAP Business Warehouse\(^{10}\) and SAP Business Objects\(^{11}\). For example, SAP HANA, the database underlying the application SAP S/4 HANA, is an in-memory\(^{12}\) technology that lets users explore and analyze all transactional and analytical data in real time from virtually any data source. This improves faster task completion which improves the currency of information and helps better decision making.

Advanced Functionality – These initiatives enable advanced functionality in SAP such as Linear Asset Management (LAM); Contracts/Supplier Management; Warehouse Management System (WMS); Vendor Electronic Enablement; Governance Risk & Compliance (GRC); and Vendor Invoice Management (VIM). For example, LAM is an enhancement within SAP Enterprise Asset Management. LAM provides management functionality for linear assets extending over long distances – like overhead electrical wires or underground cables – rather than point assets. LAM allows linear modelling and asset identification by spatial attributes for condition monitoring, order management and analytics. This functionality increases asset capability and availability – as low performance in any linear section could have negative impact on overall throughput.

The figure below illustrates how the initiatives of the ERP 2020-2024 Rate Period builds upon the foundational ERP system.

---

\(^{10}\) SAP BW – SAP Business Warehouse – also known as SAP NetWeaver – stands for business information warehouse and is an important technical module of SAP. SAP BW is a software which groups together and formats huge amounts of business data in the data warehouse. A data warehouse is software that integrates, manages and stores all the data within a company from all sources. SAP BW provides critical decision making information and also allows for multidimensional analysis.

\(^{11}\) SAP BusinessObjects BI (also known as BO or BOBJ) is a suite of front-end applications that allow business users to view, sort and analyze business intelligence data.

\(^{12}\) In-memory database technology is a database management system that primarily relies on main memory for computer data storage. Main memory is called RAM or Random Access Memory. It is contrasted with traditional database management system that employs a disk storage mechanism. RAM reduces hardware required to store the same amount of data as before. This would lead to reduced costs through simplifications in hardware, maintenance and testing in future years.
Collectively these streams comprise initiatives preliminarily identified within the program that will achieve the desired business outcomes. The selection of the initiatives; the level of scope solution; and timing will be chosen after the approval of this plan and evolving business needs. As technology, products and business needs change constantly the solution to achieve these outcomes will be refined closer to the time of implementation (start of the rate period). However, the initiatives will be prioritized and rationalized in such a manner as to limit the spending in this program to the amount approved in the 2020-2024 CIR filing. Toronto Hydro will work internally with the various business units and implement those initiatives that return the best value to the company. Also, the selection and implementation of these initiatives will be planned to avoid conflict with any other projects and ensure the initiatives meet pre-requisite dependencies.

3.2 Solution Scope

Please refer to table below for preliminary solution scope.
<table>
<thead>
<tr>
<th>Segment</th>
<th>Initiative</th>
<th>Description and scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Integration with Open Text</td>
<td>Integration with Open Text to bring in cross functional process based workflows, notifications and meta data to flow back and forth between the two systems. Eg. Integration of GCF, RCF, WCF process and process for storage and integration of picture storage for construction and inspection work. Scope - Legal and financial attachment types supported only</td>
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<tr>
<td>Integration</td>
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<td>Integration with CC&amp;B to bring in metering orders and tie them to work orders, this will also include CAF process. Scope - One to one mapping between MO and WO supported with 2 way integration.</td>
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<td>Integration</td>
<td>Integration with NMS &amp; Oracle MWM</td>
<td>The extent of Integration with NMS and Oracle MWM will depend on the scope of Oracle MWM project and details of work being performed in NMS vs. Oracle MWM. Scope - One to one mapping between NMS/Oracle MWM and SAP supported with 2 way integration.</td>
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<td>Integration</td>
<td>Integration with GIS</td>
<td>Integration with GIS to sync equipment and asset registries between two systems. The complexity depends on the choice of the solution. Scope - One to one mapping between GIS and SAP supported with 2 way integration.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Reporting Maturity</td>
<td>Enablement of Netezza and SAP BW will happen through the project however extending Netezza to satisfy all business esp. future regulatory requirements will happen over longer period of time. Scope - Carry over historical data up to two years back for regulatory related reporting only and maintain legacy for older data retrieval.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Upgrade to SAP HANA</td>
<td>We are planning to deliver SAP ECC 6.0 EHP 8.0; SAP will release the roadmap for SAP ECC – third party databases in Jan 2018. Depending on the future roadmap upgrading our SAP ECC to run on HANA may have to be eventually considered. Scope - Upgrade BI and ECC to SAP HANA.</td>
</tr>
<tr>
<td>New Functionality</td>
<td>Linear Asset Management</td>
<td>Enabling scope of linear asset management in SAP ECC will depend on creation of nomenclature in GIS and DMS to manage linear assets. This may also include updates to SAP accounting ledgers to accommodate the changes to accounting treatment of assets. Scope - Implement LAM and incorporate all linear assets through data conversion.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>SAP Patches</td>
<td>Typically every year, based on predefined schedule (schedule outlook is typically 6 months), SAP releases OSS notes / patches to various SAP components. The updates to underlying infrastructure need to be performed in conjunction to maintain stability and patch linkages. Scope - Perform a Technical upgrade only.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Data Archiving / Decommissioning Program</td>
<td>Initiative to ensure that we decommission 35 applications and enable an archiving solution. Scope - Maintain high frequency legacy for read only to account for as needed data retrieval and retire low frequency legacy (store cleansed low frequency data in BI).</td>
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<td>New Functionality</td>
<td>Ariba</td>
<td>Configuration of other modules within Strategic Sourcing Ariba Suite - Supplier performance management; adding digital signatures for approvals and documentation. Scope - Configure other modules limited to SAP data feeds and vendor collaboration enablement.</td>
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<td>Models and reports for regulatory team to support OEB Application; includes SAP BW and self serve reporting. Scope - Export structured data into BW and train staff on self serve reporting using &quot;variants&quot; (Requires BW/BI in house skills in both IT and the business).</td>
</tr>
<tr>
<td>New Functionality</td>
<td>Red Prairie</td>
<td>Bring Red Prairie (Warehouse Management System) within SAP. Scope - Perform a technical and functional upgrade and perform limited functional enhancements.</td>
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<tr>
<td>New Functionality</td>
<td>Vendor Electronic Enablement</td>
<td>Enable EDI interface through Ariba / Value Added Network (VAN) to ensure all the TH vendors are EDI enabled. Scope - Account for vendor collaboration via Ariba and VAN (hybrid).</td>
</tr>
<tr>
<td>Reporting</td>
<td>Asset Analytics</td>
<td>Enabling asset analytics interface with SAP BW and calculations in BOBJ space. Scope - Extract SAP EAM data into structured BW/BI cubes to be used as data feeds into a 3rd party Asset Analytics application.</td>
</tr>
<tr>
<td>New Functionality</td>
<td>EH&amp;S Requirements</td>
<td>Enabling EH&amp;S requirements such as Hazard rate, hazard information, MSDS and ISN information. Making it available to crews and other parties as needed. Scope - Extract data and make it available as reports and downloadable xls.</td>
</tr>
<tr>
<td>New Functionality</td>
<td>GRC</td>
<td>Enabling GRC capabilities for SAP suite. Scope - Implement SAP Audit Management and Risk Management</td>
</tr>
<tr>
<td>New Functionality</td>
<td>Successfactors Maturity</td>
<td>Enabling and maturing more seamless data flow across different successfactors modules and between SF and ECC. Enabling more self serve options for employees and managers. Scope - Interfaces external to successfactors.</td>
</tr>
<tr>
<td>New Functionality</td>
<td>A/P Invoice Processing / Management Solution (SAP / OpenText VIM)</td>
<td>Implement invoice processing and management solution (SAP/OpenText VIM). Scope - Emulate the data entry process.</td>
</tr>
</tbody>
</table>

3.3 Options Analysis

Toronto Hydro Electric System Ltd. 13
The following options have been considered:

1. Status quo / do nothing
2. Implement a simple scope solution with minimal benefits
3. Implement a moderate scope solution with benefits that are commensurate to the costs
4. Implement a complex scope solution with benefits that do not justify the higher level of costs

Each option was evaluated for the proposed focus areas for the 2020-2024 Rate Period and is summarized at a high-level in the table below:

<table>
<thead>
<tr>
<th>Options Analysis - ERP 2020-2024 Rate Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
</tr>
<tr>
<td>Status quo / do nothing</td>
</tr>
<tr>
<td>Integration with Open Text</td>
</tr>
<tr>
<td>Integration with CC&amp;B</td>
</tr>
<tr>
<td>Integration with NMS &amp; Oracle MWM</td>
</tr>
<tr>
<td>Integration with GIS</td>
</tr>
<tr>
<td>Reporting Maturity</td>
</tr>
<tr>
<td>Upgrade to SAP HANA</td>
</tr>
<tr>
<td>Linear Asset Management</td>
</tr>
<tr>
<td>SAP Patches</td>
</tr>
<tr>
<td>Data Archiving / Decommissioning Program</td>
</tr>
<tr>
<td>Ariba</td>
</tr>
<tr>
<td>Regulatory</td>
</tr>
<tr>
<td>Red Prairie</td>
</tr>
<tr>
<td>Vendor Electronic Enablement</td>
</tr>
<tr>
<td>Asset Analytics</td>
</tr>
<tr>
<td>EH&amp;S Requirements</td>
</tr>
<tr>
<td>GRC</td>
</tr>
<tr>
<td>SuccessFactors Maturity</td>
</tr>
<tr>
<td>A/P Invoice Processing / Management Solution (SAP / OpenText VIM Solution)</td>
</tr>
<tr>
<td>Total estimated cost of program</td>
</tr>
<tr>
<td>Intended benefits from program</td>
</tr>
<tr>
<td>Overall recommendation</td>
</tr>
</tbody>
</table>

**Legend**

- **Does not meet criteria**
- **Partially meets criteria**
- **Meets Criteria**
- **Exceeds Criteria**

3.4 Cost
Some of the resources from within Toronto Hydro who were involved in the ERP 2015-2019 Rate Period program may also be involved in the ERP 2020-2024 Rate Period program. To efficiently utilize these resources and to keep resources evenly distributed throughout the implementation period it is recommended to start the ERP – O & C initiatives in early 2020. Generally, most of the initiatives are relatively small in scope and scale and as such will be staggered over the five year period. Toronto Hydro intends to follow a “rolling” model of few initiatives under implementation at any given point in the rate period as opposed to a “big-bang” approach where all initiatives Go-live at the same time.

Toronto Hydro requires flexibility over the five year period to execute its ERP 2020-2024 Rate Period program. This includes flexibility to manage externally-driven risks, such as the risk that the vendor may increase software/hardware costs over the 2020 to 2024 period or change the release dates for ERP application updates and patches. Both of these events could affect the cost, timing and pacing of a program in a given year. However, based on the strategy to keep current with Tier 1 applications the amount of spending has been gradually paced to increase with later years in the rate period. The below table breaks down the historical and forecast program costs for ERP.

<table>
<thead>
<tr>
<th>Program</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP 2020 - 2024 Rate Period</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>2021</td>
</tr>
<tr>
<td></td>
<td>2022</td>
</tr>
<tr>
<td></td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>2024</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>46.3</td>
</tr>
</tbody>
</table>

Prior to investing in new IT systems, Toronto Hydro follows an evaluation methodology to help ensure that the utility makes well-informed decisions relating to new IT investments. The cost estimate of initiatives in the Sustainment stream is the combination of regular updates of notes and patches, migration to HANA database and upgrade to the SAP S/4 HANA application, and data migration and decommissioning. The cost estimate of the Enhancement stream are the total of those initiatives that the business units have preliminarily put forward as valuable to the company to achieve its goals for the 2020-2024 rate period.

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13 Details of this standard methodology is available in Exhibit2B Section D5 paragraph D.4.2.2
Preliminary Scoping Business Case – Customer Information System (CIS)
# Table of Contents

Table of Contents ................................................................. 2

1  EXECUTIVE SUMMARY .......................................................... 4

2  PROBLEM STATEMENT ........................................................... 4

   2.1  Problem Statement .......................................................... 4
   2.2  Business Requirements ...................................................... 6
   2.3  Assumptions & Dependencies ............................................. 9

3  PROPOSAL DESCRIPTION ....................................................... 9

   3.1  Options Analysis ............................................................. 10
   3.2  Working Program Approach Description ............................... 11
   3.3  Solution Scope and Cost .................................................... 11
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Document Objectives

The purpose of this document is to provide a common template that will be used for projects within the Toronto Hydro organization, initiated to remain in compliance with Toronto Hydro IT standards.
1 EXECUTIVE SUMMARY

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Information System Upgrade</td>
<td>$38.5 M</td>
</tr>
</tbody>
</table>

The purpose of this program is to upgrade the Customer Information System (“CIS”) to a version consistent with the risk mitigation objectives of Toronto Hydro’s Information Technology Asset Management Strategy. Furthermore, if the CIS is upgraded to a current version which is closely aligned to other Ontario Local Distribution Companies (“LDCs”), this will better position the utility to respond to future public policy initiatives with lower costs or shorter delivery timeframes.

The CIS stores customer account information, produces bills, applies payments to customer accounts, and optimizes activities to collect outstanding amounts. The current version of Toronto Hydro’s CIS has only been eligible for minimal vendor support since April 2016. This level of support only covers pre-existing patches and the vendor no longer addresses emerging threats to Toronto Hydro’s customer information or the accuracy of their bills. Without full vendor support, any disruption caused by a system failure will take longer to resolve as it is challenging to obtain the suitable skilled resources to resolve the issue. Toronto Hydro will incur additional costs in correcting any errors in coding or any open security vulnerabilities.

Toronto Hydro issues approximately 43,000 bills per day and any delays or inaccuracies in those bills have major customer impacts. This is in addition to any impact on revenue capture and financial reporting that would also result. Currently, Toronto Hydro minimizes these risks via additional Information Technology operating costs and additional testing of every modification to the system, no matter how small. However, the risks cannot be entirely eliminated through this approach. This tactic is only suitable in the short-term as the costs become exponentially higher the further Toronto Hydro’s CIS differs from the vendor and industry norms.

It is important to note that Toronto Hydro’s system will be at least four years out-of-support and will have been in service for 10 years before this program completes the initial upgrade. This results in the program being a substantial undertaking as it must assess the changes across five major versions of the system, interfaces with 33 other technology systems, 460 reports, 400 business processes, and 1000 configurations, and customizations. The CIS is used by 270 individuals, each of which must be retrained and whose work must remain consistent with regulatory and customer expectations.

Benefits will be attained consistent with the objectives of Toronto Hydro’s Information Technology Asset Management Strategy, such as:

- improved data security and quality including improved protection against cyber-security threats and unauthorized access to customers’ confidential information; and
- mitigation of reliability risks of CIS with an upgraded and vendor supported system.

2 PROBLEM STATEMENT

2.1 Problem Statement

Toronto Hydro is using the CIS to control and operate the meter-to-cash process responsible for the billing, payment application and collections activities for $4 billion in annual revenue or approximately $18 million per day. The CIS also manages account and personal information for approximately 764,000 customers.
As media coverage and bill accuracy perception have shown, the reliable operation of a company’s CIS is a critical part of brand and reputation, both inside and outside the electricity industry. This is in addition to the critical role the CIS plays in ensuring accurate and timely revenue capture and financial reporting.

Toronto Hydro’s CIS is five major versions behind the current version which exposes customers and the utility to increasing levels of risk as described in the bullet points below. Toronto Hydro intends to bring the CIS back into the regular Tier 1 lifecycle. However, Toronto Hydro has also had to perform long-awaited upgrades on other key systems (for example NMS and ERP) prior to doing this. Although the optimal strategy from a corporate perspective, this increases the scope, time required and cost of the initial upgrade described in this document.

Toronto Hydro implemented its current CIS in 2011. In the time since implementation, Toronto Hydro has ensured that the system remained cost effective, secure, and reliable through ongoing minor software upgrades and incremental custom development. This was done to meet evolving public policy, regulatory and business requirements. As the CIS continues to age, the risks associated with the system become more difficult to mitigate. These risks include:

- **Limited vendor support** – the system is not supported against defects or security flaws discovered after April 2016. All system changes required to meet financial, legislative or public policy requirements must be purchased or developed internally at an additional cost. Additionally, collaboration to deliver new functions or features and/or reduce costs with other LDCs is becoming increasingly difficult since the companies are operating on increasing divergent versions. For example, for recent policy changes the vendor has supplied one solution for three LDCs and a separate one for Toronto Hydro despite identical requirements.

- **Personal data security deficiencies** – Toronto Hydro’s CIS version no longer receives fixes to security gaps from the vendor. The CIS operates on aged infrastructure which in turn will have issues related to vendor support. Customer personal data and consumption information are more vulnerable to cyber security attacks such as “exploit” and “denial of service” types of attacks. “Exploit” type attacks seek to gain unauthorized access to confidential information such as customers’ personal information and bank account details. A successful “denial of service” attack would mean Toronto Hydro could not issue electricity bills, apply payments to accounts or service customer accounts.

- **Resource availability** – Toronto Hydro’s CIS includes substantial portions built with the COBOL programming language, which was first used in 1959, and is criticized for being not easily comprehensible. Due in part to this, the vendor over recent versions has replaced all COBOL programs with JAVA programs. This is a common occurrence across the computer industry and as such, COBOL programmers are both difficult to find and expensive to retain. Should a major issue occur with the CIS, it is likely that it will be sustained while suitable and sufficient resources are located.

- **Technology Enhancements** – The replacement of COBOL with JAVA and other similar changes in underlying technology and supported infrastructure will also significantly lower the effort required to implement future changes, maintain and support the system. The transition to common technologies also allows Toronto Hydro to use its internal resources more effectively as specialist skills would no longer required.

- **Integration Architecture** – Where possible, Toronto Hydro has included industry best practices in the CIS and supporting business processes. However, because of limitations in the current CIS, Toronto Hydro has invested in customizations to support the required regulatory, legislative or other Ontario market functions and features. These customizations, some of which can be delivered by standard functionality in the latest version, increase the complexity of the system, make it more expensive to support and more prone to errors unique to Toronto Hydro and its customers. Errors unique to the utility typically take a much longer to resolve since the same error is not in the current, vendor delivered code that the entire user community uses.

In the current business environment, significant opportunities exist when systems are integrated with one another. The current CIS version is difficult and expensive to integrate with other systems often to the point that potential customer service improvements are not cost effective.
or removal of modifications to the system and processes, and the implementation of new functionality. To implement any such changes, Toronto Hydro’s policies require the demonstration of benefits which are greater than the costs. Furthermore, this analysis competes against other initiatives based on net benefit for the utility.

Generally speaking, with this type of initiative, Toronto Hydro considers the following in the early stages of the project:

- **Optimization** – Toronto Hydro periodically reviews business operations and looks for optimization opportunities. By optimizing processes, Toronto Hydro is able to reduce rework and increase the quality and timing of staff outputs. Optimization also allows Toronto Hydro to create predictive mechanisms to manage outcomes and monitor efficiency and effectiveness of critical processes.

  Early consideration of opportunities for optimization, typically through automation, have flagged the following for further investigation:
  
  - Customer experience processes including customer move processing, bill and payment analytics, and customer issue management,
  - Processes related to bill presentment, electronic payments, equal payment plans processing, billing adjustments, and meter data verification,
  - Collections and severance processes, including a more segmented arrears management strategy, and
  - Exception management and audit functionality

- **Simplification** - With the evolution of public policy, growth of customer service offerings and increasingly complex billing scenarios, there may be a need to simplify the CIS architecture. The simplification process aims to evaluate the existing configuration and system setup and compare it against the flexibility that will be required in the future. Toronto Hydro has identified simplification opportunities related to system configuration and data processing between systems for further analysis. This in turn will reduce the implementation time for public policy initiatives. They may also lower the costs of related process automation and may allow for improved process controls which manage and monitor efficiency and effectiveness of customer services.

- **New functionality** - Toronto Hydro plans to further assess new functionality available in the latest version of the CIS. Initial high-level work indicates that some of Toronto Hydro’s customizations are now base CIS features. Customizations increase costs of future upgrades since they frequently require expensive vendor services and potentially proprietary code. By adopting base CIS features in place of customizations, Toronto Hydro aims to reduce future upgrade time requirements and subsequent costs.

### 2.2 Business Requirements

This section lists the key interested parties (internal/external) impacted by this solution. It identifies who is involved directly (as a recipient of the solution outcome) or indirectly (through integration/alignment with other programs and/or work processes), and their high-level requirements for the solution to meet their expectations. This early list of requirements identifies a combination of key requirements, capabilities for investigation and areas of known differences between the current CIS and the current in-market version.

<table>
<thead>
<tr>
<th>Department</th>
<th>Division</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Center</td>
<td>Customer Care</td>
<td>• Ability to process moves including setting up landlord agreements</td>
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<td></td>
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<td>• Ability to link incoming and outgoing documents to customer accounts as a part of document &amp; record management process</td>
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<td>• Ability to manage information relays between different Customer Care departments through consistent processes</td>
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<td></td>
<td></td>
<td>• Ability to update landlord information on multiple premises</td>
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<td>• Ability to produce landlord move notification letters</td>
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<td></td>
<td>• Ability to inform internal staff of marketing initiatives in a timely and consistent manner</td>
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<tr>
<td>Department</td>
<td>Division</td>
<td>Requirements</td>
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<tr>
<td></td>
<td></td>
<td>• Ability to maintain and access accurate customer data in CIS by optimizing and creating appropriate process controls (e.g. Standardize structured format to eliminate inaccurate service address, email address or phone numbers)</td>
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<td></td>
<td>• Ability to manage customer cases accurately and timely manner for customer escalations, account management and follow ups</td>
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<td></td>
<td></td>
<td>• Reduce manual effort to analyze/create billing history for analysis</td>
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<td></td>
<td>• Reports to control the process efficiency and effectiveness</td>
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<tr>
<td>Collections</td>
<td>Customer Care</td>
<td>• Optimize collections and severance process steps and controls to manage bad debt</td>
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<tr>
<td></td>
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<td>• Ability to accurately and consistently perform transfer of balance between service agreements without system automatically resetting the aging so that collections activities can be initiated as per business rules</td>
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<td>• Ability to assess/capture partial payment cases to improve severance process effectiveness</td>
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<td></td>
<td>• Ability to have segmented arrears management process and controls to maintain bad debt at acceptable levels</td>
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<td>• Enhanced controls to proactively assess and monitor accounts or customers at high risk for continued non-payment</td>
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<td>• Ability to evaluate the collection process effectiveness to create a feedback loop to CIS from auto-dialer event</td>
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<td>• Ability to segment account base based on quantitative factors to make decisions related to collections activities</td>
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<td>• Ability to view past due arrears in a single holistic view and take appropriate actions to improve average call handling time</td>
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<td>• Ability to calculate amount of deposit based on customer risk profile</td>
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<td>• Ability to process field activities</td>
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<td></td>
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<td>• Ability to apply direct deposit and deposit interest linked to customer account based on business rules</td>
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<td>• Ability to interact effectively with customer when initiating remote reconnect process</td>
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<td></td>
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<td>• Ability to send a copy of any disconnection notice issued to the customer for non-payment to a third party designated by the customer for that purpose provided that the request is made no later than the last day of the applicable minimum notice period</td>
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<td></td>
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<td>• Ability to send notices/letters through customer preferred channels</td>
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<td>• Ability to optimize the process where a disconnect field activity (FA) is outstanding (waiting for a read to be returned), a payment plan should not cancel the FA</td>
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<td></td>
<td></td>
<td>• Reports to control the process efficiency and effectiveness</td>
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<tr>
<td></td>
<td></td>
<td>• Ability to record write-offs and write-backs</td>
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<tr>
<td>Remittance</td>
<td>Customer Care</td>
<td>• Automate EFT process in CIS</td>
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<tr>
<td></td>
<td></td>
<td>• Ability to perform real time tender balancing</td>
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<td></td>
<td>• Ability to mass update system (e.g. different types of payments)</td>
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<td></td>
<td>• Ability to reverse payments for multiple accounts</td>
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<td>• Ability to evaluate the charge back reason when a payment is reversed</td>
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<td></td>
<td>• Improve PAP, NBB and payment reversal letters and review processes</td>
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<td></td>
<td>• Ability to identify and take corrective action for duplicate refunds</td>
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<td></td>
<td>• Ability to refund customer credit in automated and consistent manner</td>
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<tr>
<td></td>
<td></td>
<td>• Ability to provide equal payments plan (evaluate budget billing) in consistent manner</td>
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<tr>
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<td></td>
<td>• Optimize security deposits that needs to be refunded within 10 days of the final bill</td>
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<tr>
<td></td>
<td></td>
<td>• Improve debit adjustment process</td>
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<td>• Reports to control the process efficiency and effectiveness</td>
</tr>
<tr>
<td>Department</td>
<td>Division</td>
<td>Requirements</td>
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<td>----------------------------</td>
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</tr>
<tr>
<td>Billing</td>
<td>Customer Care</td>
<td>• Ability to disable autopay when a billing adjustment is performed until customer provides direction for repayment for billed amount</td>
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<td></td>
<td>• Workflow approval control over manual bill cancellations</td>
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<td></td>
<td></td>
<td>• Ability to control high and low bill cases consistently and accurately</td>
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<td>• Ability for customer review bill segment based on different pricing terms</td>
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<td>• Ability to optimize process with extensive manual and repetitive steps (e.g. declaration form, rate reclassification etc.)</td>
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<td>• Ability to identify and take actions for cases having zero consumption</td>
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<td></td>
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<td>• Ability to cancel multiple bills linked to customer account</td>
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<td></td>
<td>• Ability to provide credits for net metering customers accurately and consistently</td>
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<td></td>
<td>• Ability for clearing un-actionable flag from the CIS</td>
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<td>• Automation of manually produced customer letters</td>
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<tr>
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<td>• Optimize adjustment approval process (e.g. CIS allows to change the amount of the adjustment after it's already submitted for approval. This does not modify the approval threshold amounts)</td>
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<td>• Ability to bill new segment of customer accurately and consistently (e.g. new SA for FIT customers)</td>
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<td>• Ability to do a segmented bill insert for select customers on an ad-hoc basis</td>
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<td>• Ability to issue consolidated billing for customers having multiple accounts</td>
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<td>• Ability to process online payments</td>
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<td>• Ability to automatically waive account setup fee based on special cases</td>
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<td>• Ability to automatically identify if a customer is doubled billed for the period</td>
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<td>• Reduce billing segment errors for timely, &amp; accurately issuance of bill</td>
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<td>• Ability to link weather information with bill information (e.g. case of high bill)</td>
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<td>• Ability to consolidate the bill for customer having multiple accounts</td>
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<td>• Ability to evaluate significant variance in consumption through automated reminder (e.g., To Do TD-INT (Interval Profile Peak Validation) logic needs to be reviewed and updated to ensure that to dos are only generated on accounts with significant variances in consumption)</td>
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<td>• Ability to evaluate significant variance in month over month dollar amount billed</td>
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<td>• Ability to flag bill segments that have issued bills for more than one billing period (e.g. bills going out for multiple periods cause incorrect calculations on distribution and transmission rates due to bill is calculated on highest demand for whole period)</td>
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<td></td>
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<td>• Ability to flag and review the first bill segment of a new accounts where consumption or demands are outside the rate class of the customer</td>
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<td></td>
<td></td>
<td>• Reports to control the process efficiency and effectiveness</td>
</tr>
<tr>
<td>Billing and Meter Data</td>
<td>Customer Care</td>
<td>• Ability to monitor the life cycle of FA so that billing knows when a meter is energized</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td>• Proactive exception management, for e.g. ability to evaluate all the prior and immediate issues while solving an error to get a holistic view of the scenario</td>
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<td>• Automatic cycle validation, exception read from Operation Data Store (ODS)</td>
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<td></td>
<td>• Ability to automatically validate prime read meter reads</td>
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<td></td>
<td></td>
<td>• Enhance RIMS meter pending To Do’s so that correct action can be taken in timely manner</td>
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<tr>
<td></td>
<td></td>
<td>• Ability to accurately and consistently perform RIMS billing by having automated process control</td>
</tr>
</tbody>
</table>
### Department | Division | Requirements
--- | --- | ---
All Customer Care | Customer Care | • Ability to process wholesale settlement process done in MVWEB, suite meter account setup, manipulation of service point, meter change in an optimized manner
• Reports to control the process efficiency and effectiveness

• Ability to simplify the organization (chronological) or modification/deletion or reduce duplicates of same note type class of customer contact notes for reducing average customer call handling time and provide holistic view customer interaction and escalations
• Ability to communicate (proactive notifications and transaction confirmation) with customer through different communication channel
• Ability to simplify process steps and management controls for end users through proactive reminders and optimized workflows (e.g. Idle process - To create a reminder to trigger action at the time of the move out, collection & severance process etc.)
• Optimize the bill print process and improve bill appearance
• Ability to track and audit account level information
• Ability to process online payments in the CIS
• Ability to classify segment of customer based on new segment agreement definition (e.g. new SA for FIT customers)
• Ability to mass update system (e.g. different types of payments)
• Optimize the bill print process and improve bill content accuracy
• Optimize the process and content of capturing customer information (e.g. address)
• Evaluate the feasibility of driving billing change decision at account level instead of service agreement level
• Evaluate the feasibility of having one to one relationship between customer (person), account, service agreement and service point
• Evaluate the feasibility to create low/high threshold based on consumption as billing is factor of rates
• Evaluate the feasibility of creating an automated control to reduce the variance in following the business process step
• Maintain or reduce system refresh rate
• Business rules for segmentation of data for archival purposes

#### 2.3 Assumptions & Dependencies

The following assumptions have been made related to the initiation of this project:

• Project Stakeholders with executive authority to make decisions with respect to the outcomes of the project will be identified as the single point of contact for the project team throughout the project.

• Toronto Hydro staff will be available as required to support the development of the business and process designs, and system architecture.

• Deliverables which require approval by non-project team members will be reviewed within five business days, with approval not unreasonably withheld.

• Toronto Hydro Business Units will provide Subject Matter Experts to the project as required to ensure the timely completion of deliverables.

• Cost outlines high level project implementation cost doesn’t include cost for peripherals

Any change in this understanding will result in a change to the project scope and will be subject to the established change process.

#### 3 PROPOSAL DESCRIPTION
3.1 Options Analysis

The following options have been considered:

1. **Do Nothing (i.e. Delay Investment):** In this scenario, the CIS system will be maintained as-is and will continue to operate on the current version and infrastructure. Through minor incremental investment, the CIS will be sustained, where possible, to provide the minimum operational functionality required. The integration, configuration and customization will be retained as-is without any further investment.

2. **Base Technical Upgrade:** In this scenario, Toronto Hydro would identify the simplest path to upgrading the CIS system to a version fully supported by the vendor. All CIS applications interfaces and integration with other IT systems would be maintained, “as is”, with no new functionality within or additional connectivity between applications provided. Existing customizations would require case-by-case evaluation to determine the appropriate treatment.

3. **Enhanced Implementation of CIS:** In this scenario, Toronto Hydro will build upon Option 2 through targeted, incrementally expanded, and cost justified scope that seeks to maximize the use of base functionality in the new version and leverage new opportunities to enhance value to customers. The configuration and development work necessary to implement Toronto Hydro’s future state requirements would be undertaken to achieve cost reduction and productivity improvement goals.

4. **New Implementation of CIS:** In this scenario, Toronto Hydro would decommission the current CIS system, replacing it with an entirely new system. A new integration architecture around the CIS system will replace the existing architecture. All the integrated technology systems will be optimized based on current standards. The configuration and development work necessary to implement Toronto Hydro’s future state requirements would be undertaken to achieve cost reduction and productivity improvement goals. In this approach the likely first system to be considered would be SAP to leverage the recent ERP investment and skills acquired internally.

Each option was evaluated based on the following criteria:

a) Alignment with Tactical and Strategic Goals: Assessment of how well the option achieves the goals of risk reduction, improving customer satisfaction or experience, reducing costs, or improving ability to respond to public policy initiatives.

b) Solution Capability: Does the option align technologies and applications, while minimizing the amount of customization to the system.

c) Operations and Maintenance: How costly is the option to support and operate on an ongoing basis.

d) Comparative High-Level Cost vs Direct Benefits: Does the option provide direct and quantifiable benefits, and to what magnitude. How do those benefits compare to the estimated cost of the option.

See below for a high-level summary of the detailed option evaluation.

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<tr>
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</thead>
<tbody>
<tr>
<td>Alignment with Tactical and Strategic Goals</td>
<td>Red</td>
<td>Yellow</td>
<td>Green</td>
<td>Yellow</td>
</tr>
<tr>
<td>Solution Capability</td>
<td>Red</td>
<td>Yellow</td>
<td>Green</td>
<td>Yellow</td>
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<tr>
<td>Operations and Maintenance</td>
<td>Red</td>
<td>Yellow</td>
<td>Green</td>
<td>Yellow</td>
</tr>
<tr>
<td>Comparative High-Level Cost vs Direct Benefits</td>
<td>Green</td>
<td>Yellow</td>
<td>Green</td>
<td>Red</td>
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</table>
3.2 Working Program Approach Description

Toronto Hydro developed its working program approach considering the high-level options assessment and to lower the program delivery risks. As a result, Toronto Hydro is adopting the Enhanced Implementation of CIS approach based on the available information.

The first initiation and discovery step will be focused on understanding and documenting the current state and detailed requirements. Following this each requirement will be assessed and a suitable solution architected, given each requirement may have multiple ways to deliver this will be a significant undertaking. At this point greater information about opportunities is expected to be available, also the project team will have developed a greater understanding of the capabilities in the new version. Toronto Hydro will individually evaluate elements to determine if they should be added to the project scope due to positive cost justifications.

The majority of the work and cost occurs in the Implementation phase. This is due to three primary reasons. Firstly, there are more than 164 changes between Toronto Hydro’s current version and the in-market version. For each of these, Toronto Hydro must assess the impact to current business processes and associated users, how the change interacts with the 1000 customizations or 460 reports. Interfaces and technical changes must also be evaluated and addressed along with a fundamental underlying code change from COBOL to Java, requiring each portion of code written in COBOL to be located, assessed, recoded and tested in Java.

Secondly, the latest version of the CIS requires changes to underlying messaging technology as the current technology is not supported by the vendor, plus it allows all the Tier 1, highly-available infrastructure to be moved to the current standard.

The final component that primarily contributes to the time and cost of the program is the testing element, which is critical to ensure all billing, customer and regulated requirements are met. Given the number of changes that will occur during the upgrade, this will be the most labour intensive part of the program.

Finally, the program will complete the Support phase which is to address any immediate issues and support the 270 users of the new system adapt to the changes.

3.3 Solution Scope and Cost

This section outlines the scope of the solution and the associated cost required to deliver the high-level proposed solution.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Scope</th>
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<tbody>
<tr>
<td>Initiation and Discovery</td>
<td>• Governance</td>
</tr>
<tr>
<td></td>
<td>o CIS governance model</td>
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<td></td>
<td>o Core and secondary team allocation</td>
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<td></td>
<td>• Project approach</td>
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<td></td>
<td>o Workshops on CIS latest version</td>
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<tr>
<td>Stage 1: Strategize and Architect</td>
<td>Stage 2: Implementation</td>
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</table>
| o Definition and acceptance by governance body  
   o High level “Time boxed” project plan  
   o Selection of external vendor to support process definition work – latest version will be installed in-house | • Future state business and process architecture and installation of latest version to initiate a discovery exercise  
   • Creation of the blueprints for future state business processes  
   • Options evaluation – cost and benefit analysis of different methods to meet the business requirements  
   • Finalization of future state process (Level 1-2- & 3)  
   • SIPOC (suppliers, inputs, process, outputs, and customers) and business requirements document for the finalized process architecture  
   • Technical requirement finalized to support the business requirements  
   • Finalize solution architecture and supporting documentation  
   • Project charter and scoping document finalized  
   • System integrator selection - System Integrator contract for services required to support the completion and management of the program  
   • Quality management strategy  
   • Change management strategy  
   • System and user acceptance test strategy  
   • Training strategy  
   • Change readiness assessment  
   • Master data strategy  
   • Data cleansing and conversion strategy | • Finalization of blue print documentation  
   • Integrated project plan for technical and optimization phases  
   • Technical infrastructure installed, tested and deployed  
   • Interface and integration architecture  
   • Configuration and development  
   • Data architecture and clean up  
   • Unit testing  
   • System integration testing  
   • User acceptance testing  
   • Training need analysis and creation of “work day” scenarios  
   • End user process and system training  
   • “Hour-by-Hour” cutover and cutover plan  
   • Fall-back/roll back plan  
   • Support and sustainment analysis and plan  
   • Go Live  
   • Quality and go live verification  |
| | | • 90 days post go live support  
   • Roll off / transition plan execution  
   • Project closure report  |

**Cost Estimation**

Toronto Hydro Electric System Ltd.
<table>
<thead>
<tr>
<th>Program Element</th>
<th>Capex</th>
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</thead>
<tbody>
<tr>
<td>Initiation and Discovery</td>
<td>$1 million</td>
</tr>
<tr>
<td>Strategize &amp; Architect</td>
<td>$2.1 million</td>
</tr>
<tr>
<td>Implementation</td>
<td>$30.9 million</td>
</tr>
<tr>
<td>Support</td>
<td>$4.4 million</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$38.5 million</strong></td>
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</tbody>
</table>
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 71:

Reference(s): Exhibit 2B, Section E8.4, p.18

EB-2014-0116, Exhibit 2B, Section E8.6, p.3

With respect to the ERP project undertaken between 2015 and 2019:

a) Please explain in detail why the project actuals were $62.8M when they were forecast to cost $51.3M.

b) Please provide copies of any post-competition/lesson-learned or similar report that was completed. If one was not completed, please explain why not.

c) Please explain what lessons Toronto Hydro has learned regarding the ERP project that it is using for the purposes of work to be undertaken between 2020 and 2024.

RESPONSE:

a) As described in Exhibit 2B, Section E4, page 6, the variance in the ERP program over the 2015-2019 period is attributable to the following factors:

   - an additional $8.4 million resulting from additional resources that were required for the project, changes in infrastructure costs following a more detailed technical assessment, and exchange rate fluctuations;
   - an additional $1.8 million resulting from a three month schedule extension to allow the alignment of various activities and streamline project related tasks; and
an additional $1.3 million in subscription fees for SuccessFactors modules. These modules bring additional functionalities such as Compensation, Recruiting, Onboarding, Performance & Goals, Workforce Analytics & Planning and Employee Central;

b) Toronto Hydro intends to complete the lesson-learned process after the post-implementation phase of the project concludes in April 2019.

c) Toronto Hydro has learned the following lessons, which it intends to apply over the 2020-2024 period:

1. Toronto Hydro adopted leading practices which included selecting an internal team staffed with driven individuals and system implementation partner who brought industry experience and allowed the utility to identify industry best practices to adopt into the utility’s configuration.

2. Toronto Hydro minimized customization through aligning the utility’s business processes to the pre-established standard functionality embedded in the product.

3. Toronto Hydro followed strong project management practices which established effective project governance discipline within the execution of the project, including a detailed project plan, short interval controls (regular status checks, leadership and executive touch points), and risk management.

4. Toronto Hydro ensured that the configured solution supports the business processes as designed by performing thorough testing of the configuration.

5. For future initiatives, Toronto Hydro should explore sustainability options in detail to assess the transition from the project mode to ongoing operations and plan out the support requirements ahead of time, including data governance, business process management, system support, etc.
6. Toronto Hydro adopted strong internal governance processes to manage project costs utilizing short interval controls and formal change request processes to manage agreed scope.
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 72:
Reference(s): Exhibit 2B, Section E8.4, Appendix A

With respect to the Gartner ‘IT Budget Assessment Final Report’:

a) [p.8] Please explain how the peer group was selected.

b) [p.8] Provide a list of the peer group utilities.

c) [p.8] Please confirm that the revenue and operational expenses include non-distribution costs such as the cost of power.

d) If the response to part (c) is confirmed, are similar costs included in the peer group information?

e) [p.8-32] If the response to part (c) is confirmed, please revise the Toronto Hydro information, and if possible the peer groups, to show on all metrics on costs related to distribution revenue and distribution expenses.

f) Please explain why Gartner did not include an IT spending per customer metric.

g) [p.19] Gartner states in explaining why it generally bases its metrics on employees count: “Many of the IT departments Gartner works with and has in our peer benchmark database typically do not know the number of contractor labour or level of outsourcing in the lines of business, and Gartner does not normally collect a number of users”. Why would IT departments not know the number of users
that have active accounts on their systems?

h) Please provide a copy of the completed questionnaire that was provided to Toronto Hydro to collect the necessary data for the study.

RESPONSE (RESPONSES PROVIDED BY GARTNER):

a) The peer group was selected based on industry and revenue. For the benchmark of Toronto Hydro, Gartner selected utilities that had conducted a benchmarking study with Gartner within the previous 18 months, that had total annual revenue similar to THESL and that had distribution services in urban areas.

b) Gartner cannot name the members of the peer group due to confidentiality agreements with the peer organizations that are standard for all our benchmarking clients.

c) Confirmed.

d) Yes.

e) Revising Toronto Hydro’s information to show all metrics on costs related to distribution revenue and distribution expenses would be a significant burden for both Toronto Hydro and Gartner. The level of effort and time involved in doing this work would likely be similar to the original benchmark project, which ran from project kick-off on December 5, 2017, to delivery of the final report on March 16, 2018. Toronto Hydro would need to report revenue, operational expense and employees for its distribution business only (if project scope were similar, this would need to be done
for both 2017 and the 2020 projection). In addition, because Gartner benchmarks are based on an alignment of business and IT support for that business, Toronto Hydro would need to revise all IT data (total IT spending, IT spending distributions, total IT staffing levels, IT staffing distributions, and infrastructure workload measures) to align with the narrower scope (again, if project scope were similar, this would need to be done for both 2017 and the 2020 projection). Where IT spending and staffing are not tracked at this level of detail, THESL would need to provide estimates (for example, the IT spending for distribution vs non-distribution businesses for application development, application support, servers, storage, end-user computing, IT service desk, data network, voice services and IT management and admin, as well as for hardware, software, personnel and outsourcing). The accuracy of results would only be as accurate as these allocations. Gartner would need to work with Toronto Hydro through data collection, review of initial results, and any clarification or revisions to data.

Gartner does not have a break-out of peer distribution and non-distribution revenue and cost, nor a break-out of IT spending and staffing for support of distribution and non-distribution businesses and so cannot provide these calculations for the peer group.

f) Gartner does not collect data for the number of customers and so cannot calculate IT spending per customer.

g) IT departments may know the number of active accounts on their systems, but these do not always correspond one-to-one with users. There may be duplicate users or group accounts.
h) Toronto Hydro provided two data collection questionnaires, one for 2017 and one for 2020. Please see Appendix A and B, respectively.
## General Information

<table>
<thead>
<tr>
<th>Enterprise Name</th>
<th>Toronto Hydro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Industry Classification</td>
<td>Transportation, Communications, Electric, Gas</td>
</tr>
<tr>
<td>Organizational Scope of This Assessment</td>
<td>Enterprise</td>
</tr>
<tr>
<td>Currency of Financial Data Entered</td>
<td>Canadian Dollar</td>
</tr>
<tr>
<td>Fiscal Year</td>
<td>2017</td>
</tr>
<tr>
<td>Fiscal Year End (Month)</td>
<td>December</td>
</tr>
</tbody>
</table>

## Organization Profile for:

### 2016

| Annual Revenue                      | 4,016,900,442 |
| Business Operational Expense        | 3,572,680,639 |

## Organization Profile for:

### 2017

| Total Employees | 1,390 |

## Total IT Budget for:

### 2017

| IT Capital Investment | 48,193,987 |
| IT Operational Budget  | 38,869,201 |
| IT Depreciation & Amortization | 28,908,826 |

## Total IT Staffing for:

### 2017

| Total IT full time equivalents (include insourced and contractors) | 214 |
| What percent of the IT FTEs listed above are contractors? | 47% |

## IT Spending Allocation

### 2017

| Hardware | 24.27% |
| Software | 14.67% |
| Personnel Salaries & Benefits (incl. Occupancy) | 37.42% |
| Outsourcing (incl. Transmission) | 23.64% |
| Total should equal 100% | 100.00% |

## What percent of your total Capital and Operational IT Budget is to Run, Grow, and Transform the Business?

### 2017

| Run | 70.70% |
| Grow | 24.93% |
| Transform | 4.37% |
| Total should equal 100% | 100.00% |
Of your IT budget EXCLUDING capital investments and INCLUDING operational costs & amortization & depreciation ONLY, what percent of your IT budget for the fiscal year selected above is spent on:

<table>
<thead>
<tr>
<th>Service</th>
<th>2017 Percent Budget</th>
<th>2017 Percent Support (Full Time Equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Computing, Storage and Facilities</td>
<td>24.95%</td>
<td>19.03%</td>
</tr>
<tr>
<td>End-User Computing</td>
<td>6.12%</td>
<td>8.68%</td>
</tr>
<tr>
<td>IT Service Desk</td>
<td>2.28%</td>
<td>3.12%</td>
</tr>
<tr>
<td>Voice Network</td>
<td>2.83%</td>
<td>1.87%</td>
</tr>
<tr>
<td>Data Network</td>
<td>6.67%</td>
<td>5.61%</td>
</tr>
<tr>
<td>Application Development</td>
<td>2.65%</td>
<td>27.66%</td>
</tr>
<tr>
<td>Application Support</td>
<td>44.24%</td>
<td>19.55%</td>
</tr>
<tr>
<td>Corporate IT Management</td>
<td>2.63%</td>
<td>5.30%</td>
</tr>
<tr>
<td>IT Finance &amp; Administration</td>
<td>7.67%</td>
<td>9.17%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

<table>
<thead>
<tr>
<th>Service</th>
<th>2017 Percent Budget</th>
<th>Total Public Cloud Spending as a Percent of Total IT Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software as a Service (SaaS)</td>
<td>2.24%</td>
<td>3.08%</td>
</tr>
<tr>
<td>Infrastructure as a Service (IaaS)</td>
<td>0.85%</td>
<td></td>
</tr>
<tr>
<td>Platform as a Service (PaaS)</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>Total Public Cloud Spending</td>
<td>3.08%</td>
<td></td>
</tr>
</tbody>
</table>

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

<table>
<thead>
<tr>
<th>Service</th>
<th>2017 Percent Budget</th>
<th>Total Public Cloud Spending as a Percent of Total IT Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications</td>
<td>2.24%</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0.85%</td>
<td></td>
</tr>
<tr>
<td>Total Public Cloud Spending</td>
<td>3.08%</td>
<td></td>
</tr>
</tbody>
</table>

Infrastructure Workload Measures

<table>
<thead>
<tr>
<th>Resource</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainframe Total Installed MIPS</td>
<td>0</td>
</tr>
<tr>
<td>Unix Virtual Servers</td>
<td>441</td>
</tr>
<tr>
<td>Windows Virtual Servers</td>
<td>1464</td>
</tr>
<tr>
<td>Linux x86 Virtual Servers</td>
<td>252</td>
</tr>
<tr>
<td>Storage Raw TBs</td>
<td>4041</td>
</tr>
<tr>
<td>Personal Computing Devices</td>
<td>4038</td>
</tr>
<tr>
<td>Networked Peripherals</td>
<td>259</td>
</tr>
<tr>
<td>IT Service Desk Contacts</td>
<td>49301</td>
</tr>
</tbody>
</table>

END OF QUESTIONNAIRE
<table>
<thead>
<tr>
<th>General Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Name</td>
<td>Toronto Hydro</td>
</tr>
<tr>
<td>Primary Industry Classification</td>
<td>Transportation, Communications, Electric, Gas</td>
</tr>
<tr>
<td>Organizational Scope of This Assessment</td>
<td>Enterprise</td>
</tr>
<tr>
<td>Currency of Financial Data Entered</td>
<td>CANADIAN DOLLAR</td>
</tr>
<tr>
<td>Fiscal Year</td>
<td>2019</td>
</tr>
<tr>
<td>Fiscal Year End (Month)</td>
<td>December</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Organization Profile for:</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Revenue</td>
<td>4,042,485,230</td>
</tr>
<tr>
<td>Business Operational Expense</td>
<td>3,447,493,204</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization Profile for:</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employees</td>
<td>1,467</td>
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</table>

<table>
<thead>
<tr>
<th>Total IT Budget for:</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Capital Investment</td>
<td>47,097,798</td>
</tr>
<tr>
<td>IT Operational Budget</td>
<td>45,833,671</td>
</tr>
<tr>
<td>IT Depreciation &amp; Amortization</td>
<td>49,514,261</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total IT Staffing for:</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total IT full time equivalents (include insourced and contractors)</td>
<td>200</td>
</tr>
<tr>
<td>What percent of the IT FTEs listed above are contractors?</td>
<td>36%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IT Spending Allocation</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td>24.27%</td>
</tr>
<tr>
<td>Software</td>
<td>14.67%</td>
</tr>
<tr>
<td>Personnel Salaries &amp; Benefits (incl. Occupancy)</td>
<td>37.42%</td>
</tr>
<tr>
<td>Outsourcing (incl. Transmission)</td>
<td>23.64%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What percent of your total Capital and Operational IT Budget is to Run, Grow, and Transform the Business?</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>82.22%</td>
</tr>
<tr>
<td>Grow</td>
<td>11.59%</td>
</tr>
<tr>
<td>Transform</td>
<td>6.19%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Of your IT budget EXCLUDING capital investments and INCLUDING operational costs & amortization & depreciation ONLY, what percent of your IT budget for the fiscal year selected above is spent on:

<table>
<thead>
<tr>
<th>Section</th>
<th>2019 Percent Budget</th>
<th>2019 Percent Support (Full Time Equivalents)</th>
<th>Should be 2020, limitation of drop down menu.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Computing, Storage and Facilities</td>
<td>23.69%</td>
<td>18.00%</td>
<td></td>
</tr>
<tr>
<td>End-User Computing</td>
<td>5.34%</td>
<td>8.00%</td>
<td></td>
</tr>
<tr>
<td>IT Service Desk</td>
<td>1.62%</td>
<td>3.50%</td>
<td></td>
</tr>
<tr>
<td>Voice Network</td>
<td>2.14%</td>
<td>2.00%</td>
<td></td>
</tr>
<tr>
<td>Data Network</td>
<td>3.98%</td>
<td>5.50%</td>
<td></td>
</tr>
<tr>
<td>Application Development</td>
<td>1.95%</td>
<td>26.00%</td>
<td></td>
</tr>
<tr>
<td>Application Support</td>
<td>54.18%</td>
<td>18.50%</td>
<td></td>
</tr>
<tr>
<td>Corporate IT Management</td>
<td>2.07%</td>
<td>8.50%</td>
<td></td>
</tr>
<tr>
<td>IT Finance &amp; Administration</td>
<td>5.02%</td>
<td>10.00%</td>
<td></td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>100.00%</td>
<td>100.00%</td>
<td></td>
</tr>
</tbody>
</table>

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

| Software as a Service (SaaS)                | 4.45%               |                                               |                                               |
| Infrastructure as a Service (IaaS)          | 1.09%               |                                               |                                               |
| Platform as a Service (PaaS)                | 0.00%               |                                               |                                               |
| Total Public Cloud Spending as a Percent of Total IT Spending | 5.55% |                                               |                                               |

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

| Applications                                | 4.45%               |                                               |                                               |
| Infrastructure                               | 1.09%               |                                               |                                               |
| Total Public Cloud Spending as a Percent of Total IT Spending | 5.55% |                                               |                                               |

Infrastructure Workload Measures

| Mainframe Total Installed MIPS                      | 0                   |                                               |                                               |
| Unix Virtual Servers                                | 441                 |                                               |                                               |
| Windows Virtual Servers                             | 1464                |                                               |                                               |
| Linux x86 Virtual Servers                           | 252                 |                                               |                                               |
| Storage Raw TBs                                     | 4041                |                                               |                                               |
| Personal Computing Devices                          | 4038                |                                               |                                               |
| Networked Peripherals                               | 259                 |                                               |                                               |
| IT Service Desk Contacts                            | 49301               |                                               |                                               |

END OF QUESTIONNAIRE
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<tr>
<td>Fiscal Year</td>
<td>2017</td>
</tr>
<tr>
<td>Fiscal Year End (Month)</td>
<td>December</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Organization Profile for:</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Revenue</td>
<td>994,300,000</td>
</tr>
<tr>
<td>Business Operational Expense</td>
<td>920,800,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization Profile for:</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employees</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total IT Budget for:</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Capital Investment</td>
<td>45</td>
</tr>
<tr>
<td>IT Operational Budget</td>
<td>0</td>
</tr>
<tr>
<td>IT Depreciation &amp; Amortization</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total IT Staffing for:</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total IT full time equivalents (include insourced and contractors)</td>
<td>0</td>
</tr>
<tr>
<td>What percent of the IT FTEs listed above are contractors?</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IT Spending Allocation</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td>0.00% $11,331,173</td>
</tr>
<tr>
<td>Software</td>
<td>0.00% $33,566,625</td>
</tr>
<tr>
<td>Personnel Salaries &amp; Benefits (incl. Occupancy)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Outsourcing (incl. Transmission)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What percent of your total Capital and Operational IT Budget is to Run, Grow, and Transform the Business?</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>66.49%</td>
</tr>
<tr>
<td>Grow</td>
<td>20.34%</td>
</tr>
<tr>
<td>Transform</td>
<td>13.17%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Of your IT budget EXCLUDING capital investments and INCLUDING operational costs & amortization & depreciation ONLY, what percent of your IT budget for the fiscal year selected above is spent on:

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<tr>
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<th>2017 Percent Budget</th>
<th>2017 Percent Support (Full Time Equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Computing, Storage and Facilities</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>End-User Computing</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>IT Service Desk</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Voice Network</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Data Network</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Application Development</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Application Support</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Corporate IT Management</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>IT Finance &amp; Administration</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total should equal 100%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

<table>
<thead>
<tr>
<th>Service</th>
<th>2017 Percent Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software as a Service (SaaS)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Infrastructure as a Service (IaaS)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Platform as a Service (PaaS)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total Public Cloud Spending as a Percent of Total IT Spending</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Budget Distribution of Public Cloud Spending as a Percent of Total IT Spending

<table>
<thead>
<tr>
<th>Service</th>
<th>2017 Percent Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications</td>
<td>0.00%</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total Public Cloud Spending as a Percent of Total IT Spending</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Infrastructure Workload Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainframe Total Installed MIPS</td>
<td>0</td>
</tr>
<tr>
<td>Unix Virtual Servers</td>
<td>0</td>
</tr>
<tr>
<td>Windows Virtual Servers</td>
<td>0</td>
</tr>
<tr>
<td>Linux x86 Virtual Servers</td>
<td>0</td>
</tr>
<tr>
<td>Personal Computing Devices</td>
<td>0</td>
</tr>
<tr>
<td>Networked Peripherals</td>
<td>0</td>
</tr>
<tr>
<td>IT Service Desk Contacts</td>
<td>0</td>
</tr>
</tbody>
</table>

END OF QUESTIONNAIRE

Release Date - 26 July 2017
RESPONSES TO SCHOOL ENERGY COALITION INTERROGATORIES

INTERROGATORY 73:
Reference(s): Exhibit 2B

Please provide the percentage of Toronto Hydro’s capital expenditures for each year, between 2015 and 2024, by capital program that are undertaken by third-party contractors.

RESPONSE:
Toronto Hydro is not able to complete this analysis in the timeline provided for interrogatory responses. However, Toronto Hydro has provided the requested information breakdown at the investment category level. Please refer to Appendix A for third-party contractor costs compared to capital expenditures for 2015-2017 historical years. 2018 actuals are not available at this time. Third party contractor costs for 2018-2024 will depend on the mix of work executed each year.
<table>
<thead>
<tr>
<th>Categories</th>
<th>2015 Total Capex</th>
<th>2016 Total Capex</th>
<th>2017 Total Capex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIFRS in $millions</td>
<td>MIFRS in $millions</td>
<td>MIFRS in $millions</td>
</tr>
<tr>
<td>System Access</td>
<td>58.3</td>
<td>79.0</td>
<td>65.5</td>
</tr>
<tr>
<td></td>
<td>48.5</td>
<td>54.4</td>
<td>48.2</td>
</tr>
<tr>
<td></td>
<td>83.1%</td>
<td>68.9%</td>
<td>73.6%</td>
</tr>
<tr>
<td>System Renewal</td>
<td>304.1</td>
<td>266.1</td>
<td>250.3</td>
</tr>
<tr>
<td></td>
<td>169.7</td>
<td>137.8</td>
<td>120.2</td>
</tr>
<tr>
<td></td>
<td>55.8%</td>
<td>51.8%</td>
<td>48.0%</td>
</tr>
<tr>
<td>System Service</td>
<td>37.9</td>
<td>53.3</td>
<td>72.4</td>
</tr>
<tr>
<td></td>
<td>26.7</td>
<td>37.2</td>
<td>54.1</td>
</tr>
<tr>
<td></td>
<td>70.4%</td>
<td>69.8%</td>
<td>74.7%</td>
</tr>
<tr>
<td>General Plant</td>
<td>79.4</td>
<td>109.5</td>
<td>98.9</td>
</tr>
<tr>
<td></td>
<td>57.2</td>
<td>74.7</td>
<td>71.7</td>
</tr>
<tr>
<td></td>
<td>72.1%</td>
<td>68.2%</td>
<td>72.5%</td>
</tr>
<tr>
<td>Other</td>
<td>11.6</td>
<td>3.7</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>(1.3)</td>
<td>0.3</td>
<td>(1.1)</td>
</tr>
<tr>
<td></td>
<td>-10.9%</td>
<td>8.5%</td>
<td>-9.9%</td>
</tr>
<tr>
<td>Subtotal</td>
<td>491.4</td>
<td>511.6</td>
<td>497.8</td>
</tr>
<tr>
<td></td>
<td>300.8</td>
<td>304.4</td>
<td>293.1</td>
</tr>
<tr>
<td></td>
<td>61.2%</td>
<td>59.5%</td>
<td>58.9%</td>
</tr>
</tbody>
</table>
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 10:
Reference(s): Exhibit 2B, Section A4

a) Please list the capital projects that have been included in the distribution system plan with the specific objective of reducing reducing outages due to defective equipment. (sic)

b) Does THESL have any plans to monitor and measure the impact of any such capital programs on its proposed SAIDI/SAIFI -Defective Equipment metrics?

RESPONSE:

a) All programs in Toronto Hydro’s System Renewal portfolio (Exhibit 2B, Section E6) are expected to contribute directly to the utility’s system reliability outcome objectives of maintaining SAIDI and SAIFI caused by Defective Equipment as detailed in the Outcomes and Measures tables presented in each program.

The following OM&A Programs (Exhibit 4A, Tab 2) are also expected to contribute to these same reliability outcome objectives:

- Schedule 1: Preventative and Predictive Overhead Line Maintenance
- Schedule 2: Preventative and Predictive Underground Line Maintenance
- Schedule 3: Preventative and Predictive Station Maintenance
- Schedule 4: Corrective Maintenance
Note that reducing outages caused by defective equipment is not the sole objective of any of these programs.

b) The SAIDI/SAIFI Defective Equipment metrics are themselves the primary measure of the impact of Toronto Hydro’s system renewal and maintenance programs on defective equipment outages over time. It should be noted that reliability measures are necessarily lagging indicators of performance and therefore include the effects of investments made over many years. Examples of leading indicators of future Defective Equipment outages include asset age and condition.
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 11:

Reference(s): Exhibit 2B, Section C2

Table 1: 2020-2024 Custom Performance Scorecard Measures

<table>
<thead>
<tr>
<th>Toronto Hydro Outcome</th>
<th>OEB Reporting Category</th>
<th>Toronto Hydro’s Custom Measures</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Service</td>
<td>Customer Satisfaction</td>
<td>Customers on eBills</td>
<td>Improve</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety</td>
<td>Total Recorded Injury Frequency</td>
<td>Maintain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Box Construction Conversion</td>
<td>Improve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network Units Modernization</td>
<td>Improve</td>
</tr>
<tr>
<td>Reliability</td>
<td>System Reliability</td>
<td>SAIDI - Defective Equipment</td>
<td>Maintain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAIFI - Defective Equipment</td>
<td>Maintain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FESI 7 System</td>
<td>Improve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FESI-6 Large Customers</td>
<td>Maintain</td>
</tr>
<tr>
<td>Asset Management</td>
<td>System Capacity</td>
<td></td>
<td>Monitor</td>
</tr>
<tr>
<td></td>
<td>System Health (Asset Condition) – Wood Poles</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Buried Cable Replacement</td>
<td></td>
<td>Monitor</td>
</tr>
<tr>
<td></td>
<td>Average Wood Pole Replacement</td>
<td></td>
<td>Monitor</td>
</tr>
<tr>
<td></td>
<td>Vegetation Management Cost per Km</td>
<td></td>
<td>Monitor</td>
</tr>
<tr>
<td>Financial</td>
<td>Cost Control</td>
<td>Oil Spills Containing PCBs</td>
<td>Improve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste Diversion Rate</td>
<td>Monitor</td>
</tr>
</tbody>
</table>

a) Please explain why THESL has not chosen to pursue specific (numeric) performance metrics in each year of its rate plan.
RESPONSE:

Toronto Hydro provided targets without specific (numeric) values in each year of the 2020-2024 plan for a number of reasons. One reason is that certain custom measures, such as System Health (Asset Condition) – Wood Poles and Average Wood Pole Replacement Cost are new and do not have the requisite historical data to appropriately determine targets. Another reason is that the performance target for a number of measures, such as SAIDI and SAIFI, is to “maintain”, therefore the historical values are instructive for evaluating performance. Lastly, certain measures, such as Direct Buried Cable Replacement and Box Construction Conversion are dependent on the specific projects that Toronto Hydro plans to execute in over the plan. Given the early nature of these planned initiatives, Toronto Hydro is unable to forecast the specific (numeric) results that it expects to attain from these initiatives. For these measures, Toronto Hydro believes that the appropriate and reasonable time to assess the results, continuation or replacement of particular measures, and target-setting, is the end of the 2020-2024 period.
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 12:

Reference(s): Exhibit 2B, Section D1

a) What changes have been made to THESL’s asset management assessment process/systems as compared to its previous cost of service application? Specifically please explain what improvements in asset assessment have been made since that time.

RESPONSE:

Please refer to Toronto Hydro’s response to interrogatory 2B-SEC-35.
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 13:

Reference(s): Exhibit 2B, Section E4, p. 9

Table 3: System Access: 2015-2024 Expenditures ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Access</td>
<td>58.3</td>
<td>79.0</td>
<td>65.5</td>
</tr>
</tbody>
</table>

a) Please provide the actual and forecast capital contributions associated with the expenditures shown in Table 3.

b) Please provide the actual and forecast new connections forecast by rate class (or if unavailable by low and high voltage) for each of the years.

RESPONSE:

a) Please see Table 1 below.

Table 1: System Access: 2015-2024 Expenditures ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td>97.4</td>
<td>113.0</td>
<td>113.0</td>
</tr>
<tr>
<td>Capital Contributions</td>
<td>(39.0)</td>
<td>(34.0)</td>
<td>(47.5)</td>
</tr>
<tr>
<td>Net</td>
<td>58.3</td>
<td>79.0</td>
<td>65.5</td>
</tr>
</tbody>
</table>
b) Toronto Hydro is unable to provide a forecast of new connections. As discussed in Exhibit 2B, Section E5.1.4.1, the number of load connections is difficult to forecast; however, a forecast of customer numbers is available in Exhibit 3, Appendix A-1.
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION INTERROGATORIES

INTERROGATORY 14:

Reference(s): Exhibit 2B, Section E6.1

a) Please provide a table which shows for each year 2015 through 2024 the actual and expected area conversions capital expenditures.

b) For each year indicate what percentage of km of circuit (line) was replaced on a “like-for-like” basis and what percentage was a replacement of above ground for underground plant.

RESPONSE:

a) Please refer to Exhibit 2B, Section E6.1.4, Table 8, page 20.

b) None (i.e. 0%) of the planned Area Conversion projects within the program involve replacement on a “like-for-like” basis. Box Construction is replaced with the standardised overhead system, while Rear Lot is replaced with standardised underground front lot.
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 15:

Reference(s): Exhibit 2B, Section E6.1

Table 8: Historical & Forecast Program Costs ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear-Lot Conversion</td>
<td></td>
<td>26.7</td>
<td>14.5</td>
<td>8.2</td>
<td>5.7</td>
<td>10.0</td>
<td>18.8</td>
<td>26.3</td>
<td>25.2</td>
<td>28.3</td>
<td>14.9</td>
</tr>
<tr>
<td>Box Construction Conversion</td>
<td></td>
<td>19.6</td>
<td>13.6</td>
<td>18.7</td>
<td>34.3</td>
<td>34.4</td>
<td>22.7</td>
<td>20.8</td>
<td>21.1</td>
<td>22.0</td>
<td>20.7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>46.3</td>
<td>28.1</td>
<td>26.9</td>
<td>40.0</td>
<td>44.4</td>
<td>41.4</td>
<td>47.2</td>
<td>46.3</td>
<td>50.4</td>
<td>35.6</td>
</tr>
</tbody>
</table>

a) What is the total current population (2018) of box construction plant?

What is the expected population at the end of 2024?

b) Please amend Table 8 to show the number of box conversions in each year.

RESPONSE:

a) As of the end of 2018, Toronto Hydro estimates that there were approximately 4,900 Box Construction poles remaining on the system (the aforementioned figure is an estimate given that Toronto Hydro has not yet completed a review of all project attainments from 2018).

At the end of 2024, Toronto Hydro forecasts that there will be approximately 1,100 Box Construction poles on the system. Please see Exhibit 2B, Section E6.1, page 24,
b) Table 8: Amended to include Box Construction Poles

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Bridge</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box Construction Conversion ($M)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.6</td>
<td>13.6</td>
<td>18.7</td>
<td>34.3</td>
</tr>
<tr>
<td># of Box Conversion Poles Replaced</td>
<td>727</td>
<td>978</td>
<td>717</td>
</tr>
</tbody>
</table>
RESPONSES TO VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORIES

INTERROGATORY 16:

Reference(s): Exhibit 2B, Section E8.3

a) Why is THESL’s fleet budget increasing beginning in 2020 by around twice its historical pattern?

b) Do Table 6 and 7 represent all THESL vehicles? If not please amend the tables to include all vehicles.

c) Please provide similar tables for the years 2015 through 2019.

RESPONSE:

a) As explained in Exhibit 2B, Section 8.3.4.1, in the 2015-2019 period, Toronto Hydro required funding for 62 heavy duty vehicles and 199 light duty vehicles. In the current 2020-2024 plan period, Toronto Hydro requires funding for 101 heavy duty and 159 light duty vehicles. Heavy duty vehicles are typically five to ten times more costly than light duty vehicles, and have been more significantly impacted by exchange rate fluctuations given that some of the customization requirements are sourced from the United States. As vehicles age, they incur higher operating expenses due to increasing levels of reactive repairs. Therefore, if the recommended replacements are not completed during the 2020-2024 period, operating costs for repairs will increase with the escalating average age of the fleet.
b) Tables 6 and 7 include all Toronto Hydro heavy duty and light duty vehicles forecasted for replacement in the 2020-2024 period. Not all vehicles are due for replacement in this period. Refer to Tables 1 and 2 from part c) of this response for the total vehicle counts per class. As under-utilized and redundant vehicles are identified in the fleet, net reductions can and will be expected in lieu of replacements throughout the 2020 to 2024 period, however forecasts in Exhibit 2B, E8.3.4.1, Tables 6 and 7 were built off the fleet size, distribution, and needs at the time of forecasting.

c) The following table depicts the number of vehicles by type that have been replaced (2015-2018), and are scheduled to be replaced (2019), from each year from 2015 to 2019, as well as the total number of each vehicle per class in each year.¹

Table 1: Replacement Costs For Heavy Vehicles In-Serviced for the 2015 to 2019 Period ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cube Van (Replacements)</td>
<td>16</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Cube Vans (Total)</td>
<td>56</td>
<td>50</td>
<td>50</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Van w Aerial Device (Replacements)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Van w Aerial Device (Total)</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Truck (Replacements)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0.1</td>
</tr>
<tr>
<td>Line Truck (Total)</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Bucket Truck (Replacements)</td>
<td>3</td>
<td>0.8</td>
<td>5</td>
<td>1.4</td>
<td>9</td>
<td>2.7</td>
<td>5</td>
<td>1.6</td>
<td>8</td>
<td>2.8</td>
<td>9.2</td>
</tr>
<tr>
<td>Single Bucket Truck (Total)</td>
<td>77</td>
<td>75</td>
<td>70</td>
<td>63</td>
<td>63</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Tables 1 & 2 display the year the vehicle was put into service, and the full acquisition cost of those vehicles. The acquisition cost is often spread over the lead time of the vehicle, with components being received ahead of putting the full vehicle into service, therefore, these tabulated costs will not fully align with the total capital spend for the year as reported in Exhibit 2B – E8.3.4, Table 4.
Table 2: Replacement Costs For Light Duty Vehicles In-Serviced for the 2015 to 2019 Period ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports Utility Vehicle (Replacements)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0.2</td>
<td>0</td>
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<tr>
<td>Sports Utility Vehicle (Total)</td>
<td>32</td>
<td>33</td>
<td>32</td>
<td>36</td>
<td>94</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>1.3</td>
</tr>
<tr>
<td>Pick-Up Truck (Replacements)</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Pick-Up Truck (Total)</td>
<td>94</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>1.3</td>
</tr>
<tr>
<td>Minivan – Passenger (Replacements)</td>
<td>5</td>
<td>0.1</td>
<td>7</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>Minivan – Passenger (Total)</td>
<td>17</td>
<td>19</td>
<td>17</td>
<td>13</td>
<td>17</td>
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<td>17</td>
<td>13</td>
<td>17</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Panel: General Plant, Operations, and Administration
<table>
<thead>
<tr>
<th>Description</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minivan – Cargo (Replacements)</td>
<td>5</td>
<td>15</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>Minivan – Cargo (Total)</td>
<td>67</td>
<td>58</td>
<td>56</td>
<td>51</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Full Size Van – Cargo (Replacements)</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>6</td>
<td>0.8</td>
</tr>
<tr>
<td>Full Size Van – Cargo (Total)</td>
<td>47</td>
<td>46</td>
<td>47</td>
<td>43</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>Cars (Replacements)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0.3</td>
</tr>
<tr>
<td>Cars (Total)</td>
<td>18</td>
<td>17</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Total Replacements</td>
<td>10</td>
<td>36</td>
<td>14</td>
<td>26</td>
<td>26</td>
<td>1.3</td>
</tr>
<tr>
<td>Total Light Duty Fleet</td>
<td>275</td>
<td>266</td>
<td>262</td>
<td>257</td>
<td>257</td>
<td>4.5</td>
</tr>
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