ONTARIO ENERGY BOARD
File No. EB-2018-0165
Exhibit No. K6.2
Date July 8, 2019 jfs

Toronto-Hydro Electric System Limited

EB-2018-0165

Norman Hann Compendium

Panel 2

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 buy 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 96:

Reference(s): **Exhibit 4A, Tab 2, Schedule 5**
Figure 3: Fallen Tree on Power Lines from November 15, 2017 Wind Storm, p. 7 of 18

a) What is the root cause of the interruption in Figure 3: Fallen Tree on Power Lines from November 15, 2017 Wind Storm according to the THESL training guide?

RESPONSE:

a) As noted, a severe wind storm affected the city. This picture is an example of damages caused by a tree blown down and contacting Toronto Hydro's overhead plant. Wind direction, wind speed and tree planting proximity to the overhead plant and lines are all key factors. The line clearing program by forestry teams may have prevented contact of this tree under standard conditions but would not manage tree lifespan or age factors. Considering what is shown in the picture, considerable rot conditions within the tree may also have played into the result.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 97:

Reference(s): **Exhibit 4A, Tab 2, Schedule 5, p. 9 of 18, lines 1-20**

a) What is the criteria for invoking mutual assistance from other utilities and contractors?

b) How often has THESL requested assistance?

c) How long did it take to request assistance from the beginning of the storm?

d) How long did it take for assistance to arrive?

RESPONSE:

a) Mutual aid is invoked when emergency response needs (specifically resource needs) exceed locally available resources, when mutual aid resources can be acquired within an appropriate amount of time, and when the acquisition of mutual aid resources is expected to have a material impact on overall restoration time. Given that resource status and conditions can vary significantly from event to event, the points at which mutual aid will be invoked will correspondingly vary. Factors that are considered when the usefulness of mutual aid is being evaluated may include, but are not limited to:

- Emergency conditions (i.e. type/scope of damage);
- Availability of internal resources (both number of resources and type of resources) whose skills are required to assist in restoration;

- Availability of partners' resources for deployment--in some cases, mutual aid partners may also be impacted by an event simultaneously and are unavailable to assist; and
- Expected duration of the event and partners' distance from impact site (e.g. if restoration is expected to take 3 days, but it will take 2 days for partners' crews to mobilize, this may impact the request for resources).

b) Toronto Hydro has requested mutual assistance once, during the 2013 ice storm event.

c) The Greater Toronto Area was impacted by the event on December 21st and December 22nd 2013. Toronto Hydro began reaching out to off-system resources on the afternoon of December 22nd 2013.

d) A majority of the mutual assistance crews arrived in approximately two days.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 98:

Reference(s): Exhibit 4A, Tab 2, Schedule 5, p. 10 of 18
Figure 6: Examples of Wind 1 Damage Recent 2018 Storm

a) Did THESL do a post storm analysis on the failures shown in Fig 6?

b) Were the class of poles the correct size for all the conductors and cable attachments on the poles?

c) How old were the poles?

d) If no post storm analysis was done on Figure 6: Examples of Wind 1 Damage Recent 2018 Storm failures, are post storm analysis done on other events? Please provide the results of those analysis for major interruptions. [sic]

RESPONSE:

a) No, there was no post-storm analysis conducted on the poles shown in Figure 6.

b) Yes, Toronto Hydro's pole sizes and associated attachments (cables, conductors, etc.) are consistent with design and construction standards.

c) The poles shown in Figure 6 were within their expected life span for this construction. At the time of the event, the poles in the picture on the left were approximately 57 years old and the pole in the picture on the right was approximately 24 years old.

d) Post-storm analysis is not usually conducted on equipment that fails during storm events, as the damage is usually caused by the extreme event conditions. Damage assessment, response prioritization, and completion/restoration activities follow based on crew availability and other competing priorities at the time. However, post-storm analysis on failed equipment may be a component of overall storm response analysis, such as the Final Report prepared for the Toronto Hydro Independent Review Panel by Davies Consulting after the 2013 ice storm.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 107:

Reference(s): Exhibit 4A, Tab 2, Schedule 11, p. 8 of 10, lines 1-8

a) Does the GPS in the truck record where the work was actually performed?

b) If yes, is that data used to identify the trouble spots on the feeder instead of the interrupting device?

RESPONSE:

a) No, the GPS does not record where the work was performed.

b) Not applicable.

overall event management and dynamically guides the response efforts to safe and efficient outcomes. Some staff are deployed into secondary roles within the ICS structure. Oversight by the ICS team of restoration efforts are maximized via the resource complement scheduled and field staff for each shift. Ramp down management and guidance by the ICS team is also required for safe and careful closure to the event thus ensuring all staff can return to regular duties and schedules with assurance of the requisite rest periods.

Should an event reach a scale and scope that would be beyond reasonable expectations for restoration of customers, Mutual Aid may be called upon. The 2013 Ice Storm was the one example of such a request and deployment of Mutual Aid.

Table 1: Level 3 Emergency & Mutual Assistance requested (2009-2018)

Name of Event	Dates	No. of Interruptions	No. of Customers Out (Interruptions)	Number of Staff and Contractor Levels Per Shift	Number of EM Team Members (IMS Roles) per shift	Declaration Type
2018 May Windstorm	May 4-May 7, 2018	N/A	~68,000	50-250	10-25	Level III
2018 April Spring Storm	April 14-18, 2018	N/A	~51,000	30-120	10-25	Level III
2013 Ice Storm	December 22, 2013 - January 1, 2014	N/A	~313,000	700-1400	25-35	Level III

Note 1: Toronto Hydro utilizes all available resources for Level 3 events.
Note 2: Data is from 2013-2018. Toronto Hydro cannot provide comparable information prior to 2013.
Note 3: No. of Interruptions is not a quantifiable figure since various system events can have nested outages/interruptions associated with restoring power (e.g. isolating and segmenting around an impacted area to minimize customers out).
Note 4: '*No. of Customers Out (Interruptions)*' refers to total peak customers out of power during the event
Note 5: 2013 Ice Storm was the only event during the specified range which required inbound Mutual Assistance
Note 6: Staff & EM team levels are approximate due to the various stages and start/stop times of different shifts for each response.

TECHNICAL CONFERENCE UNDERTAKING RESPONSES TO ND HANN

UNDERTAKING NO. JTC 3.12:

Reference(s): **4A-Staff-126**

To determine whether records exist of deficiency reviews with manufacturers, and whether they can be provided.

RESPONSE:

Toronto Hydro has a robust quality management process for identifying and rectifying equipment deficiencies. The process is documented in the utility's Supplier Quality Manual, which is provided to all suppliers that the utility contract with. Suppliers are contractually required to ensure that the equipment provided to Toronto Hydro is safe, reliable and meets Toronto Hydro's quality standards.

Suppliers must establish and maintain a system and accompanying procedures, such as testing, to ensure that all products conform to Toronto Hydro's requirements and conditions contained in the purchase agreements, technical specifications and industry standards. Toronto Hydro regularly exercises its on-site quality audit rights to verify that suppliers are meeting these obligation and has completed 18 audits during the 2015-2018 period.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 122:

Reference(s): **Exhibit 4B, Tab 2, Schedule 3 – 2016 Tax Return REDACTED, UPDATED, p. 47 of the PDF file, lines 41-55, section 244**

a) This work was done in 2015, tested in 2016, additional meters were installed in 2017 and 2018. The evidence states that "The outage / 47. restoration event data can be fed to Outage Management System." Is it fed or is it not fed to the Outage Management System. [sic]

b) If not, why not and when will it operational?

RESPONSE:

a) Toronto Hydro completed phase 1 of the Network Management System (NMS) upgrade in 2018 and looks to integrate "last gasp" data in the new NMS system during NMS Phase 2 (2019-2020).

b) Please refer to response (a).

resource planning or ERP system. This investment is needed to ensure that our version of the software continues to be supported by the vendor. That's the run portion.

We are also planning to make enhancements to address business risks and enable better integration and information exchange. That's how we grow, and in doing all of the work, it can help us become more efficient in streamlining manual processes, the transformation piece.

Fleet and facilities programs are the next within general plant. The primary objective of these programs is to maintain safety and reliability of the assets that we rely on every day to do our work.

Within facilities, we have 207 stations and four work centres. Since the last application, we have improved our asset management practices in this area. We now assess, tag, and meticulously log the condition of each discrete asset in our facilities. This improved practice is expected to decrease asset lifecycle costs over time by helping us target the highest priority replacements and maintenance activities.

Moving on to fleet, safe and reliable vehicles support our operations and help us execute our capital and maintenance programs. On the basis of the lifecycle analysis and asset condition assessments, we see a need to invest in heavy duty vehicles, which can cost more than five times of light duty vehicles. So although the total number of vehicles that we propose to replace in this application is the same as a last time, our funding

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 6:

Reference(s): **Exhibit 1B, Tab 1, Schedule 1, pp. 13, 14 of 34, lines 3-9 and 1 Table 1 Months of Extreme Weather (January 1 2017 through June 2018)**

What are the design loads for wind in KPH and/or ice in mm including overload factors?

RESPONSE:

For overhead systems, 12.5 mm radial thickness of ice, 400 N/m^2 horizontal wind loading, and -20 degree Celsius temperature are used to determine loads and maximum tensions. These values are based on CSA C22.3 No. 1 "Overhead Systems" standard.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Former Toronto	230	192	174	197	132	186	140	137	145	126
Horseshoe	1,618	1,563	1,990	1,741	1,464	1,784	1,749	1,219	1,304	1,097

Table 2: Number of Customer Interruptions

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Former Toronto	178,580	154,448	194,336	168,098	94,683	126,464	108,655	106,197	91,943	89,369
Horseshoe	1,024,692	970,705	1,034,847	975,297	906,076	915,837	909,515	974,789	967,244	1,001,473

Table 3: Sum of Durations of Interruptions

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Former Toronto	32,720	23,395	30,046	32,125	22,713	58,708	28,744	21,779	31,523	32,669
Horseshoe	307,013	298,080	393,321	363,515	290,002	378,735	345,700	268,776	259,653	227,824

Table 4: Number of Customer Hours Interrupted

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Former Toronto	124,960	223,196	188,931	213,381	139,716	135,539	145,891	120,008	160,113	191,061
Horseshoe	722,926	723,540	709,656	793,428	592,699	691,883	590,646	668,804	562,694	561,400

in population will require additional accommodation, commercial spaces and services.[10] This growth is also reinforced by the projected GDP growth anticipated for the City, which is expected to be around 2 percent per annum for the period of 2020-2024.

As illustrated in Figure 2, from 2007 to 2017, Toronto Hydro connected approximately 88,000 customers, representing a 13 percent increase in its customer base (average of 1.3 percent per year), and approximately 49,000 customers from 2012 to 2017, representing a 7 percent increase (average of 1.4 percent per year). Similar levels of growth are expected for the 2020-2024 period, as described in the Customer Forecast Section.[11] These additional customers were connected to Toronto Hydro's distribution system as a result of the investments in the Load Connection segment.

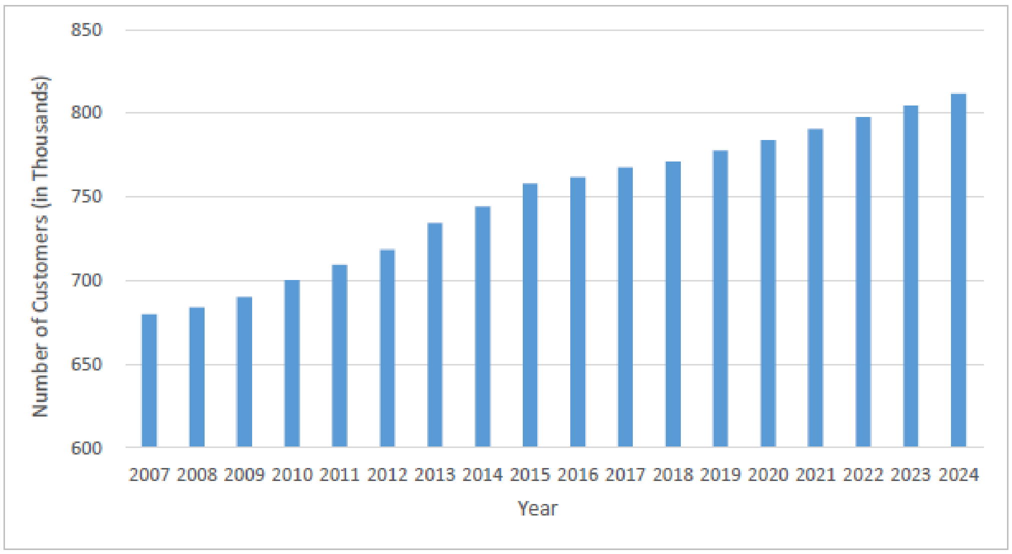

Figure 2: Historical and Forecast Number of Toronto Hydro Customers

Customer connections can be in the form of a basic connection, or a connection requiring expansion work. The types of connections Toronto Hydro performs can generally be divided into two categories as follows:

10 As of 2017, Toronto continues to lead in the number of major buildings under construction, ranking second in tall building construction after New York (Toronto Economic Bulletin, May 25, 2018).

11 Exhibit 3, Tab 1, Schedule 1.

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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 1: Equipment Failures due to Lightning Storms from 2011-2018

Equipment Type	# of Units Damaged
Cable, MV	1
Lightning Arrestor	2
Pole	1
Switch, 3PH Manual Loadbreak	1
Switch, SCADA Loadbreak	1
Transformer, Padmount	4

Equipment Type	# of Units Damaged
Transformer, Polemount	23
Transformer, Submersible	4

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)

Year	Number of Failures
2008	12
2009	8
2010	4
2011	8
2012	6
2013	4
2014	19
2015	12

2016	3
2017	7
2018	7

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."

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of Failures	0	3	2	0	3	2	2	0	0	1

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 2: Number of Transformer Failures by Ambient Temperature

Temperature Range	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Greater than 30°C	1	0	28	7	9	9	2	5	11	7

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 86:

Reference(s): **Exhibit 4A, Tab 2, Schedule 1, p. 11 line 10-26, 12 line 1-25 of 40 Pg 25 , 26 (sic)**

a) What does a deficiency in a switch look like as a result of aging?

b) Or a conductor?

c) Is there corrosion on new and old equipment?

RESPONSE:

a) Deficiencies are not always caused by aging equipment and can be caused by external factors such as the environment an asset is installed in and the conditions to which it is subjected to. Please see Exhibit 4A, Tab 2, Schedule 1, pages 20-21 for a list of common failure modes for overhead switches and a picture of an example of a defect for a broken switch insulator.

b) As per part a), deficiencies are not always caused by aging. Common deficiencies for conductor wires include sagging wires, broken/frayed wires, and wires in close proximity to vegetation.

c) Corrosion may appear on both older and younger assets and is not always dependent on the age of the equipment.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 87:

Reference(s): **Exhibit 4A, Tab 2, Schedule 1, p. 11 line 10-26, 12 line 1-25 of 40 Pg 25 , 26 (sic)**

How many wood poles have failed (by year 2008-2017) without external forces being applied e.g. motor vehicle, trees etc. ? to put another way, just due to wind or ice and no other influences? [sic]

RESPONSE:

Toronto Hydro does not have the granularity of data available to provide distribution poles that have failed "just due to wind or ice and no other influences". However, please note that Exhibit 4A, Tab 2, Schedule 1, page 13 states that Toronto Hydro, through its pole inspection program, has condemned for replacement on average over 290 wood poles annually.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 116:

Reference(s): **Exhibit 4B, Tab 2, Schedule 3 – 2016 Tax Return REDACTED, UPDATED, p. 22 of the PDF file, lines 1-11, section 242**

What is THESL's the definition of a storm day?

RESPONSE:

"Storm days" is used to broadly refer to adverse weather events including those described in Exhibit 2B, Section A4, page 13. These may include, but are not limited to, any storm events with high winds, heavy rain, freezing rain, etc.

Please also refer to Toronto Hydro's response to interrogatory 1B-Hann-1.

Recent extreme weather events (see Table 4, below) have repeatedly and pervasively affected Toronto Hydro's customers. Extreme weather events in 2017 resulted in a 72 percent increase in the number of customer interruptions attributed to tree contacts compared to the average of the previous five years. Similarly, in 2018, Toronto Hydro experienced four extreme storms during the first half of the year.

These circumstances drive Toronto Hydro to continue emphasizing plans and programs that facilitate and improve its system resiliency and ability to respond to these events. This is reflected in the fact that all of the utility's investment categories include at least some investments that support this objective. System Renewal work – and especially the renewal of legacy asset types – will contribute to system hardening by improving asset health and introducing updated equipment design and construction standards that are better suited to the changing operating environment. Grid modernization efforts in the System Access,[5] System Renewal, [6] System Service,[7] and General Plant[8] categories will help the utility respond to major events more effectively. Neglecting to make these investments during the 2020-2024 period could leave the utility ill-prepared for the effects of climate change, leading to a potential decline in service and higher costs related to reactive and emergency scenarios.

Table 4: Extreme Weather Events since the Beginning of 2017

Event	Description
Freezing Rain (February 2017)	• Approximately 2-6 mm of freezing rain followed by additional heavy rain. • Estimated 9,200 customers out at peak; all customers restored within 24 hours of the start of the freezing rain event.
High-water/flooding (May - June 2017)	• Heavy rainfall in southern Ontario exceeded the yearly average for an entire summer. • Numerous incidents of high-water/flooding reported across Toronto. • No customers were directly impacted during this 55-day incident due to the utility's proactive damage assessment and DPM mitigation measures, including flood mitigation efforts.

[5] For example, replacing end-of-life meters with next-generation smart meters.
[6] For example, replacing end-of-life stations assets with assets equipped with modern SCADA-enabled remote monitoring and control capabilities.
[7] For example, installing remote sensing capabilities in network vaults to detect floods before they damage equipment.
[8] For example, creating a fully functional dual control centre (refer to Section E8.1).

Climate change is a significant factor influencing Toronto Hydro's planning and operations. By the year 2050, Toronto's climate is forecast to be significantly different than the already changing climate seen today. For example, in Toronto, daily maximum temperatures over 25°C are expected to occur 106 times per year as opposed to 66 times per year currently. Daily maximum temperatures over 40°C, which have historically been an anomaly, are projected to occur up to seven times per year by 2050.[3] A warmer climate will also allow the atmosphere to hold more moisture, which is expected to lead to more frequent and severe extreme weather events such as ice storms and extreme rainfall events. These extreme events can cause major disruptions to Toronto Hydro's distribution system.

Not only are these weather conditions projected to occur more frequently and with greater severity in the future due to climate change, but trends from the past 20 years suggest that these changes are already affecting the system. Figure 4 below depicts cumulative rainfall and the number of high wind days in Toronto over the past 20 years. With respect to rainfall, seven of the 10 highest rain fall years have occurred in the last 10 years. Similarly, six of the 10 years with the greatest number of days of wind gusts above 70 kilometres per hour have also occurred in the last 10 years.

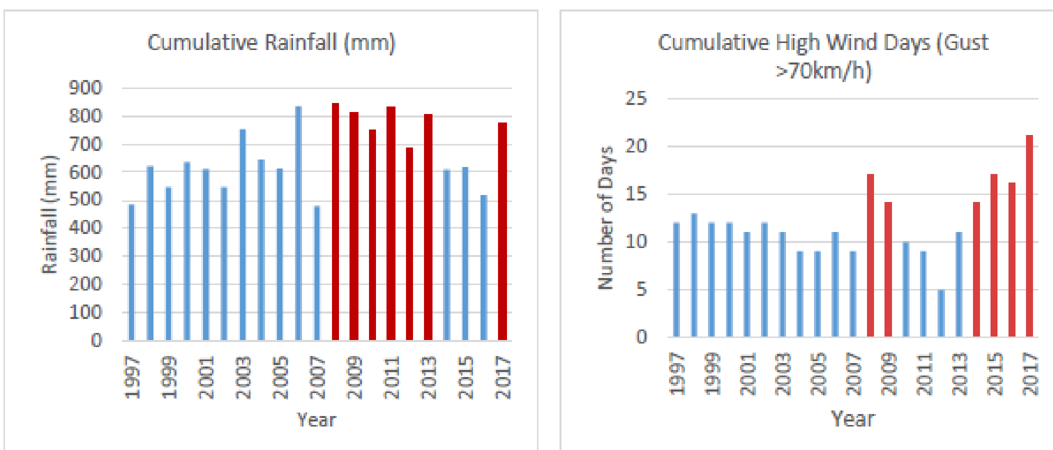

Figure 4: Cumulative Rainfall (left) and Number of High Wind Days (right) in Toronto[4]

[3] See Appendix D to Section D – Toronto Hydro-Electric System Limited Climate Change Vulnerability Assessment by AECOM (June 2015)
[4] Weather data compiled using Toronto Lester B. Pearson INTL A for January 1997 to June 2013 and Toronto INTL A for July 2013 to December 2017. Available from: Government of Canada, Weather, Climate and Hazard Historical Data online: <http://climate.weather.gc.ca/historical_data/search_historic_data_e.html>

assessment identified areas of vulnerability to Toronto Hydro's infrastructure as a result of climate change. Following this study, a climate change adaptation road map was developed, along with initiatives relating to climate data validation, review of equipment specifications, and review of the load forecasting model.

Existing codes, standards, and regulations were developed with regard to historical weather data and do not always account for ongoing and future changes to the climate. In efforts to close this gap, Toronto Hydro now utilizes climate data projections for temperature, rainfall, and freezing rain in its equipment specifications and station load forecasting. Further, Toronto Hydro reviewed and updated major equipment specifications in 2016 to adapt to climate change, including:

- Revisions to submersible transformer specifications to require stainless steel construction and testing of the equipment's ability to withstand fully flooded conditions;
- Replacement of air-vented, padmounted switches with new standard SF_6 sealed-type, padmounted switches to remove risk of failure due to ingress of dirt and road contaminants on the live (i.e. energized) surface;
- Initiation of trials of solid dielectric transformers that do not contain oil and are designed to withstand extreme environmental conditions underground; and
- 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.

As part of the climate change adaptation roadmap, Toronto Hydro conducted analyses between 2016 and 2017 to better understand how assets and operational practices could be impacted by climate change:

1) An asset impact review that looked at how each type of asset is affected by the different aspects of climate change. Resulting recommendations for each type of asset were used to alter maintenance and asset management programs.
2) An industry review of climate adaptation best practices that included an evaluation of other major utilities as well as published papers. Vegetation management practices, system hardening practices, design criteria, and maintenance practices were areas identified as being affected by climate change.
3) An emergency restoration analysis to evaluate various strategies in the event of a failure in the underground electrical distribution infrastructure when load switching or re-routing is

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 128:

Reference(s): **Exhibit 4B, Tab 2, Schedule 3 – 2016 Tax Return REDACTED, UPDATED, p. 45 of the PDF file, lines 23-27, section 246**

What are the failure causes for the studied equipment, by equipment type?

RESPONSE:

Please see Tables 1 and 2 below.

Table 1: Failure Causes by Equipment Type

Equipment Type	Root Causes
Transformer, CSP	Unknown, End of Life, Known Issue, Process, External
Transformer, Network	Unknown, Secondary Failure, End of Life, Process, Supplier Quality, External
Transformer, Padmount	Process, End of Life, External, Unknown, Lightning Strike, Supplier Quality, Secondary Failure, Overload, Overvoltage
Transformer, Polemount	End of Life, External, Process, Unknown, Supplier Quality, Secondary Failure, Lightning Strike, Overload, Overvoltage, Known Issue, Shipping & Handling, Compliance
Transformer, Station	End of Life
Transformer, Submersible	Supplier Quality, Process, End of Life, Overload, External, Secondary Failure, Unknown, Lightning Strike, Known Issue, Shipping & Handling, Overvoltage
Transformer, Vault	End of Life, Supplier Quality, External, Unknown, Overload, Secondary Failure, Known Issue, Process, Overvoltage, Shipping & Handling
Transformer, Other	External, Supplier Quality, Process, Overload, End of Life, Unknown, Lightning Strike
Circuit Breaker	End of Life, Process, Unknown, External

Equipment Type	Root Causes
Switchgear	Supplier Quality, Process, External, Unknown, End of Life, Secondary Failure, Known Issue
Switch, Manual	Unknown, External, Process, Supplier Quality, End of Life, Lightning Strike
Switch, SCADA	Unknown, Supplier Quality, Process, Known Issue, External, End of Life, Shipping & Handling
Switch, Other	Unknown, Supplier Quality, End of Life, Process, External, Known Issue
Network Protector	Process, Supplier Quality, External, Unknown
Pole, Guy Wire, Anchor	Process, End of Life, External, Unknown, Supplier Quality, Secondary Failure, Lightning Strike, Overload, Overvoltage, Known Issue, Shipping & Handling, Compliance
O/H Conductor Hardware	Supplier Quality, Process
Surge/Lightning Arrester	Unknown, External, Supplier Quality, Known Issue, End of Life
Insulator	Unknown, External, End of Life, Supplier Quality, Known Issue, Process
Cable	Unknown, End of Life, Process, External, Supplier Quality, Secondary Failure, Known Issue, Overload, Compliance
Splice/Termination	Process, Unknown, Supplier Quality, Secondary Failure, End of Life, External, Overload, Compliance
Fuse	Supplier Quality, Process, Known Issue, Unknown, External,
Crew Equipment/Tools	Supplier Quality, Process, End of Life, Unknown, Known Issue, External
Metering	Supplier Quality, Process, End of Life, Unknown, External
Misc. Vault Equipment	External, Supplier Quality, End of Life, Known Issue, Process
Communication	Supplier Quality, End of Life, Process, Secondary Failure, Known Issue, External, Unknown
Other	External, Unknown, Process, Supplier Quality, End of Life

Table 2: Failure Cause Definitions

Root Cause	Definition
Process	Caused by an internal process; may be further subcategorized as an issue with the design, installation, maintenance, operation, or standards/specifications.
Supplier Quality	Caused by the supplier/manufacturer; includes manufacturing issues, insufficient or lack of manufacturing procedures, product design, inadequate packaging, or damage from supplier, final inspection failure, failed/incorrect test reports.
End of Life	Unit has met or exceeded its useful life.
Unknown	Not enough information to root cause the failure.
External	Caused by events/conditions outside of the failed asset; includes animal contact, corrosion, contamination, extreme weather (for major event days), hit by vehicle, triggered by another failure, tampering (stealing, vandalism), and tree contact.
Overload	The unit was overloaded.
Secondary Failure	Failure on the secondary triggered a failure of the asset.
Known Issue	This is a known issue that has been investigated before and programs are already in place to correct this issue from future occurrence.
Lightning Strike	Lightning strike caused damage to the asset through means of overvoltage.
Overvoltage	Lightning/Switching/Other – failed due to transients or surges.
Shipping & Handling	Damage caused by shipping and handling within our own facilities or from our suppliers.
Compliance	Failed due to lack of adherence to standards.

RESPONSES TO ND HANN INTERROGATORIES

INTERROGATORY 129:

Reference(s): Exhibit 4B, Tab 2, Schedule 3 – 2016 Tax Return REDACTED, UPDATED, p. 45 of the PDF file, lines 23-27, section 246

What are the "new methodologies and strategies in improving 27. reliability and repeatability of distribution system assets"? [sic]

RESPONSE:

To drive improvements to standards and equipment, and thus improve the reliability of distribution system assets, Toronto Hydro develops strategies by investigating distribution equipment failures and identifying and analyzing the root cause (using the Root Cause Analysis (RCO) methodology). Depending on the nature of the root cause identified, various preventative actions can be used to mitigate reoccurrences of the same failure mode.

For example, if the root cause stems from a manufacturing defect, Toronto Hydro coordinates with the manufacturer to implement preventative measures at the facility and to perform manufacturing audits to verify the effectiveness of the measure(s). Where the root cause is attributed to an internal process issue, Toronto Hydro may release a bulletin, engage the relevant personnel in a safety meeting, or consider updating its Construction Standards and/or purchasing specifications.

For more details on Toronto Hydro's standards and practice review process, please refer to Exhibit 2B, Section D1.2.5.

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Figure 19 above shows an increase from 2017 to 2018 in the Loss of Supply impact on SAIDI.

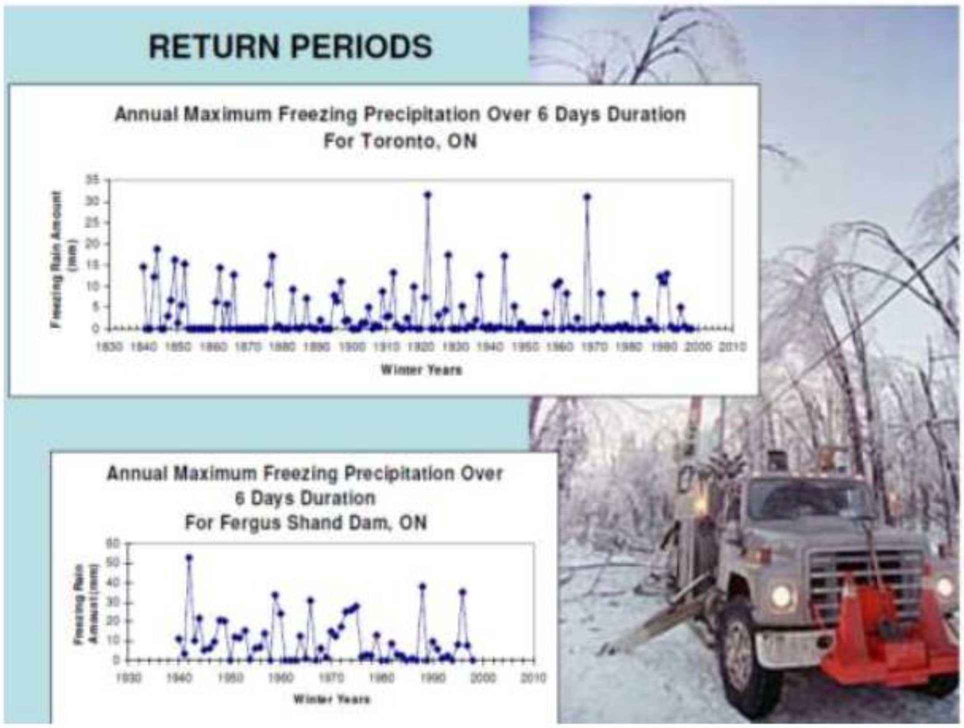
6.3 Major Event Days

Major Event Days ("MEDs") experienced by Toronto Hydro since 2013 are shown in Table 4, below, including those in 2018.

Table 4: Major Event Days (including 2018)

Dates	Description	Number of Outages	Total Customers Interrupted	Total Customer Hours Interrupted
July 8, 2013	Major Storm (Thunderstorm)	56	324,672	2,377,913
July 9, 2013	Major Storm (Thunderstorm)	44	41,502	91,646
December 21, 2013	Freezing Rain Ice Storm	42	175,928	3,204,481
December 22, 2013	Freezing Rain Ice Storm	208	441,547	8,295,093
December 23, 2013	Freezing Rain Ice Storm	25	29,530	196,633
December 24, 2013	Freezing Rain Ice Storm	23	13,983	149,337
December 25, 2013	Freezing Rain Ice Storm	18	20,225	92,924
December 26, 2013	Freezing Rain Ice Storm	20	19,147	91,458
April 15, 2014	Loss of Supply to Manby TS	27	113,035	129,479
June 17, 2014	Major Thunderstorm	38	55,442	88,496
November 24, 2014	Wind Storm	46	82,053	99,027
March 3, 2015	Freezing Rain	49	107,242	291,672
October 15, 2017	Wind Storm	31	43,175	107,846
April 4, 2018	Wind Storm	68	97,378	112,230
April 15, 2018	Freezing Rain	47	85,281	164,214
May 4, 2018	Wind Storm	98	164,261	800,390
June 13, 2018	Wind Storm	31	35,366	96,504
July 28, 2018	Loss of Supply Finch TS (Tx Fire)	22	45,475	192,195

exceed the design loading (including the overload factor) of the assets of the Toronto Hydro system and the number times (including the overload factor) the CSA Standard for Pole Line Hardware and Wood pole design has been exceeded since 1840 as was done in the 2013 Ice storm report. (see http://www.iclr.org/images/2004_Nov_ICLR_Final_ICE_STORMS.pdf Page 17 for reference)?
Severe Ice Storm Risks in Ontario - Heather Auld Joan Klaassen M Geast, S Cheng, E Ros, R Lee
Meteorological Service of Canada Environment Canada-Ontario Region



Major Event Days

The evidence refers to Major Event Days or "MED" as defined by IEEE specification 1366.

a) Please provide the actual "Major Event Day (MED) Thresholds for exclusion", dates and descriptions of the events from 2005 to 2018.
b) Please provide the expected "Major Event Day Thresholds" from 2014 to 2018(year to date - ytd) using just the 2008 to 2012 data which will provide expected performance in the future years and then compare it to the actual performance for 2014-2018 (ytd)
c) Please recalculate SAIDI and SAIFI based on "reduced days in the year" due to MED exclusions. Eg. If there were 10 MED than the "customer hours/customers served" should be factored so that it is based on 355 days and then normalized to 365 days to give a true year of year comparison.

Please show evidence as to why the events in Table 4 below are extreme events since they did not exceed the design loads with overload factor applied?

Table 4: Extreme Weather Events since the Beginning of 2017

Event	Description
Freezing Rain (February 2017)	• Approximately 2-6 mm of freezing rain followed by additional heavy rain. • Estimated 9,200 customers out at peak; all customers restored within 24 hours of the start of the freezing rain event.
High-water/flooding (May - June 2017)	• Heavy rainfall in southern Ontario exceeded the yearly average for an entire summer. • Numerous incidents of high-water/flooding reported across Toronto. • No customers were directly impacted during this 55-day incident due to the utility's proactive damage assessment and DPM mitigation measures, including flood mitigation efforts.
Wind Storm (October 2017)	• Strong wind gusts approaching 100 km/h in some areas and lasting approximately 3 hours. • Estimated 43,000 customers out at peak. • 90 percent of customers restored within 11 hours of event; all customers restored within 48 hours of the end of the event.
Wind storm (April 2018)	• Sustained 65km/h winds, with gusts approaching 90km/h. • Estimated 24,000 customers out at peak; all customers restored within 48 hours of the end of the event.
Ice Storm (April 2018)	• Approximately 10-20 mm of freezing rain, 20-25 mm rain, sustained winds of 70 km/h with gusts up to 110 km/h. • Estimated 51,000 customers out at peak. • 99 percent of customers restored within first two days of response; all impacted customers restored within 5 days of the start of the event.
Wind Storm (May 2018)	• High winds reported throughout service territory with gusts reaching approximately 120 km/h. • Estimated 68,000 customers out at peak. • 96 percent of customers restored within 48 hours of the start of the event.
Flash Storm (June 2018)	• High winds reported throughout service territory with gusts reaching approximately 90-100/h. • Estimated 16,500 customers out at peak. • 86 percent of customers restored within the first 12 hours and 97 percent of customers restored within the first 24 hours of the event.

Changing Urban Environment

Please note the change in the urban environment from some simple photos.

Blue spruce – photo taken in 1969 Blue Spruce photo taken Nov 2018

Please note that these 2 trees are on the same property separated by 49 years. This is one small example of how the urban vegetation environment has changed.

Another example is root system support failure. This tree's root system is contained on 3 of 4 sides. The lack of horizontal room for growth of the root system makes the tree vulnerable to wind and ice load above the ground so 40 years ago, this tree would have not caused an interruption or damage to the system. Today it would even though the house may have experience the same ice or wind storm 50 years apart.

Figure 12: Deterioration at the base of a pole

Toronto Hydro examined the current and projected health scores of its wood pole population to ensure the proposed pacing of wood pole replacement could prevent failure risk across this asset class from worsening over the forecast period. As shown in Figure 13 below, about a third of Toronto Hydro's are showing at least material deterioration, with approximately 11,000 poles in each of the HI4 ("material deterioration") and HI5 ("end-of-serviceable life") condition bands. The utility projects this number could nearly triple to an estimated 34,000 by 2024 without intervention, including an increase in HI5 poles from approximately 1,000 to 17,000. The Overhead System Renewal program budgets for approximately 13,000 pole replacements between 2018 and 2024. Combined with pole replacements in the Area Conversions program and the Reactive Capital program, and prioritizing poles within or nearing the HI5 category, Toronto Hydro anticipates that its 2020-2024 expenditure plan as proposed is sufficient to manage wood pole failure risk.

Wood pole replacement is the highest-volume renewal activity out of the subset of assets that are analyzed through Toronto Hydro's ACA methodology. Given the importance of managing the overall condition-informed failure risk for this asset class over the planning period, the utility is proposing to track and report on wood pole condition demographics as a Custom Performance Measure over the 2020-2024 period (see Section C for more details).

Madam Chair. I mean, we don't know the basis of the information, where it came from.

I know my friend is indicating it is coming from Environment Canada. The most that this reveals is that this is a trend. Whether or not that is the basis of its calculation or whatever else, I don't know if we can agree or disagree with respect to that. I don't think it is something within the purview of these witnesses.

MS. ANDERSON: Mr. Ladanyi, I think Mr. Keizer has a point.

MR. LADANYI: Yes. I heard his point. I will put it another way.

Does Toronto Hydro have any information that would be contrary to this? For example, let's turn to page 14, which is specific to Toronto. Do you have any information that is different that would say -- that would, let's say, prove your statement that there is increased frequency of severe weather?

MR. TAKI: Mr. Ladanyi, I would like to take you to -- there is a section in our evidence where we talk about extreme weather, and it provides a number of examples that hopefully will help address the question.

So if you go to Exhibit 2B, section A-4, and you go to page 12. You will see that we have provided a figure there -- actually, two charts. One of them is for cumulative rainfall and the other one is cumulative high-wind days. And what we've indicated there is that the days with the highest -- the ten days with the highest cumulative rainfall have occurred, as you can tell in the red, in the more recent years, and similarly as it relates to cumulative high-wind days.

And if you move to the next page, Table 4, we've described a number of extreme weather events that we have experienced over the last few years that demonstrate the statement that we started off with in this dialogue, that Toronto Hydro is experiencing more events around extreme weather.

MR. LADANYI: I see that. If I could draw your attention to the letter from the Minister of Environment, Honourable Catherine McKenna, and what exhibit is that, please?

MR. MILLAR: 2.5.

MR. LADANYI: 2.5? Okay. In the middle of that letter, there is a sentence. It says:

> "Extreme precipitation is also projected to increase in the future, although the observation on the record has not shown evidence of consistent changes in short-duration precipitation extremes across the country."

So although there is a lot of other things in the letter -- and you can certainly refer to it -- here the Minister McKenna says that in fact the Ministry -- or the Department of Environment and Climate Change Canada does not have any evidence that there is a persistent or consistent change in short-duration precipitation. There's certainly isolated events, but -- as you pointed out, but interrogatories, which is Hann 6. I'm just looking -- is that in your compendium or...

MR. HANN: Yes. It is on page 8.

MR. TAKI: Thank you. Thanks.

So in that interrogatory we have described the design loads for wind and ice.

MR. HANN: Yes. But you have not included the overload factor. Would you please provide me with the overload or the factor of safety used for wind and ice loads?

MR. TAKI: Can you define what overload factor is from your perspective?

MR. HANN: Overload factor is what is used in designing any structure to -- for factor of safety because of unknown events or loads. It is used in the industry to design transmission distribution facilities. I am surprised you don't know what an overload factor is.

MR. TAKI: Mr. Hann, the overhead CSA and underground standards to which we design do not use the word "overload factor".

MR. HANN: What word do you use, to design your poles?

MR. TAKI: We follow the CSA overhead and underground standards, and what's in the response to Hann 6 are the design loads that we design to.

MR. HANN: So you use an overload factor of 1?

MR. TAKI: No, Mr. Hann. What I said was we follow those specific standards, and in those standards there's no use of the phrase "overload factor". And the design loads of the optimal replacement time for most units within the class. Nevertheless, an asset's condition is the final determinative factor in deciding whether or not it will be replaced.

Further, exceptions to the above recommended lifespans may arise depending on specific considerations that may necessitate vehicle replacement ahead of schedule. These considerations include, but are not limited to, average maintenance costs, obsolescence, and unsuitability for the task, poor reliability, excessive downtime and non-availability of parts or accident damage beyond repair. In addition, specialized heavy vehicle replacements are routinely evaluated on an individual basis, irrespective of the schedule. This is primarily due to the critical role heavy duty vehicles play, their costs and the longer lead times required for their procurement.

Expenditure planning for capital replacements begin several years in advance due to the lead time required to procure vehicles. The lead time for heavy duty vehicles, which are of the highest priority and costliest type, is the longest at 1.5-2 years. This is due to the high degree of complexity and specialization required to be responsive to utility functions, as well as the involvement of multiple vendors.

E8.3.4.1 Heavy and Light Duty Vehicles

The number of light and heavy duty vehicles Toronto Hydro is proposing to replace in the current plan period is virtually identical to what was proposed in the 2015-2019 plan period (260 vehicles versus 261 vehicles, respectively).[4] However, in the 2015-2019 period, Toronto Hydro required funding for 62 heavy duty 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. In other words, in the 2020-2024 period, Toronto Hydro requires 63 percent more heavy duty vehicles.

For the 2015-2019 period, 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. Heavy duty vehicles are typically five to ten times more costly than light duty vehicles. As can be seen in Tables 6 and 7, below, an average bucket truck (a heavy duty vehicle) costs $350,000-$450,000, whereas a pick-up or SUV (a light duty vehicle) will cost $35,000-$45,000. In addition, heavy duty vehicles have

[4] EB-2014-0116, Toronto Hydro-Electric System Limited Application (Filed July 31, 2014), Exhibit 2B, Section E8.1, p. 9.

1 been more significantly impacted by exchange rate fluctuations given that some of the customization
2 requirements are sourced from the U.S.

3 **Table 6: Replacement Costs[5] For Heavy Duty Vehicles for the 2020 to 2024 Period ($ Millions)**

Description	2020		2021		2022		2023		2024		Total Cost
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	
Cube Van	4	0.5	2	0.3	5	0.7	0	0	7	1.0	2.5
Van With Aerial Device	3	0.3	0	0	3	0.4	0	0	0	0	0.7
Line Truck	2	0.3	0	0	0	0	1	0.1	0	0	0.4
Single Bucket Truck	7	2.6	10	3.8	6	2.4	5	1.9	4	1.6	12.3
Double Bucket Truck	3	1.3	2	0.9	7	3.1	5	2.3	6	2.7	10.2
Cable Truck	0	0	2	1.0	0	0	0	0	0	0	1.0
Small Crane Truck	0	0	1	0.3	1	0.3	2	0.5	0	0	1.0
Large Crane Truck	0	0	0	0	0	0	1	0.5	0	0	0.5
Small Derrick Truck	1	0.4	1	0.4	1	0.4	1	0.4	0	0	1.6
Large Derrick Truck	1	0.4	0	0	0	0	2	0.9	1	0.4	1.7
Dump Truck	0	0	0	0	0	0	3	0.7	3	0.8	1.5
Total	21	5.8	18	6.6	23	7.2	20	7.4	21	6.5	33.5

4 **Table 7: Replacement Costs[6] For Light Duty Vehicles for the 2020 to 2024 Period ($ Millions)**

Description	2020		2021		2022		2023		2024		Total Cost
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	
Sports Utility Vehicle	25	1.1	0	0	0	0	0	0	0	0	1.1
Pick-Up Truck	15	0.8	15	0.7	15	0.9	15	0.9	13	0.8	4.1
Minivan - Passenger	3	0.1	0	0	0	0	0	0	0	0	0.1
Minivan - Cargo	3	0.1	17	0.8	0	0	0	0	0	0	1.0
Full Size Van - Cargo	10	0.5	12	0.6	5	0.3	5	0.3	6	0.3	2.0
Total	56	2.7	44	2.2	20	1.2	20	1.2	19	1.1	8.3

[5] These costs are inclusive of all up-fitting necessary for the job, such as storage bins, partitions, racking, lighting, additional power supply; and any other aftermarket additions required in a particular light duty vehicle.
[6] Ibid.

K3-2_PWU_CEM_Compendium_Panel 1_June28_20190703 (3)
K4-2_N Hann_Appendix D Transmission LIne Design Criteria_Panel 1_20190704
K4-3_N Hann_Beaufort windscale table_20190704
K4-4_N Hann_Charts_THESL reliability_Panel 1_20190704
K4-8_EP_Fleet Services Comparison_p14 Compendium__Panel 2_2019 (3)