INTERROGATORY RESPONSE - CCC-46

CCC-46

EXHIBIT REFERENCE:

Ex. 2-4-3, p. 136, Figure 6.1

SUBJECT AREA: Distribution System Plan

Figure 6.1 provides Overall Asset Age Demographics.

Please provide a version of Figure 6.1 at the time of Hydro Ottawa's last application EB-2015-0004 and confirm the vintage of the information.

RESPONSE:

Please see the response to interrogatory CCC-45 part (c).

INTERROGATORY RESPONSE - CCC-47

CCC-47

EXHIBIT REFERENCE:

Ex. 2-4-3, p. 138, Figure 6.2

SUBJECT AREA: Distribution System Plan

Hydro Ottawa indicates 17% of assets are in Poor or Very Poor condition and overall asset condition ratings are summarized in Figure 6.2.

a) Please confirm the vintage of the data in Figure 6.2 is December 2018.

b) Please identify the party that undertook the Asset Condition Assessment (ACA) analysis and identify the ACA methodology used.

c) Please provide a version of Figure 6.2 that reflects the same information (% of assets in very poor, poor, fair, good and very good condition) at the time of Hydro Ottawa's last application EB-2015-0004 and confirm the vintage of the information.

d) Please provide a summary from 2010 onwards of when Hydro Ottawa has conducted an ACA and include the party that undertook the assessment, the methodology followed and the percentage of assets in very poor, poor, fair, good and very good condition at each assessment.

RESPONSE:

a) Yes, the vintage of the data in Figure 6.2 is as of December 2018.

b) Internal Hydro Ottawa staff was used to perform the ACA analysis. The ACA methodology used was developed for Hydro Ottawa by a third-party service provider. A description of the methodology can be found in this Application in section 5.3 of Attachment 2-4-3(G): Strategic Asset Management Plan.

c) A summary of percentage of assets in Poor and Critical Condition from Hydro Ottawa's previous rebasing application can be found in Table 2.2.5 below, as it originally appeared in Exhibit B-1-2: Distribution System Plan.[1] The vintage of information in the table is as of the end of 2014.

Table 2.2.5 - Asset Demographics & Condition

Asset Type	Population	Average Age	% in Poor & Critical Condition
Poles	59,450	39	12%
Polemounted Transformers	15,663	30	11%
Kiosk & Padmounted Transformers	15,633	33	4%
Vault Transformers	3,474	34	7%
Distribution Cables (XLPE)	4,128 km	25	17%
Distribution Cables (PILC)	356 km	35	15%
Underground Switchgear	439	15	2%
Station Transformers	170	36	2%
Station Breakers	1,003	36	5%

d) Hydro Ottawa did not use the current ACA framework prior to 2018. Since then, Hydro Ottawa has used internal staff to perform and complete the analysis, using the ACA method described in this Application in section 5.3 of Attachment 2-4-3(G): Strategic Asset Management Plan. ACA analysis was last used on Hydro Ottawa's asset data as of December 2018. The results of the analysis appear in this Application.

Hydro Ottawa's previous ACA analysis completed by internal staff can be found in Hydro Ottawa's previous application in section 2.2.3 of Exhibit 2-4-3: Distribution System Plan.[2]

[1] Hydro Ottawa Limited, *2016-2020 Custom Incentive Rate-Setting Distribution Rate Application*, EB-2015-0004 (April 29, 2015).
[2] *Ibid.*

Prior to 2015, Hydro Ottawa's ACA framework was still in development and Hydro Ottawa is therefore unable to provide results dating back to 2010.

INTERROGATORY RESPONSE - CCC-48

CCC-48

EXHIBIT REFERENCE:

Ex. 2-4-3, p. 138-193

SUBJECT AREA: Distribution System Plan

Hydro Ottawa provides Condition Demographics for its assets.

a) Please complete the attached excel spreadsheet (CCC_IR_48).

b) Has Hydro Ottawa undertaken a gap analysis that looks for any additional condition testing information that is currently being undertaken in the industry that Hydro Ottawa is not doing, that could be undertaken by Hydro Ottawa to improve the accuracy of its condition assessment results? If yes, please explain.

RESPONSE:

a) Please refer to excel Attachment CCC-48(A): Asset Condition Demographics.

b) As part of the review of Hydro Ottawa's Asset Condition Assessment framework, METSCO highlighted gaps in the utility's data collection for each asset class. Please refer to Attachment CCC-60(A): Hydro Ottawa ACA Review - Initial Assessment and Attachment CCC-60(B): Hydro Ottawa ACA Review - Follow up Assessment for further details.

INTERROGATORY RESPONSE - CCC-49

CCC-49

EXHIBIT REFERENCE:

Ex. 2-4-2, p. 194

SUBJECT AREA: Distribution System Plan

Assets identified of needing corrective action are evaluated to determine the appropriate action. Options evaluated are Repair, Refurbish or Replace. Please provide the number of Corrective Maintenance requests related to each of Repair, Refurbish or Replace for each of the years 2015 to 2019 and discuss any trends over time.

RESPONSE:

Hydro Ottawa does not track the level of detail to distinguish between Repair, Refurbish, or Replace. However, the utility does track expenditures for maintenance (Repair and Refurbish) and capital (Replace).

For maintenance costs, please refer to UPDATED Attachment 4-1-3(A): OEB Appendix 2-JA - Summary of Recoverable OM&A, submitted as an update to this Application on May 5, 2020. Maintenance costs increased from 2016 to 2017 and decreased from 2018 to 2019.

For Corrective Renewal Program Expenditure, please refer to Table 1.78 in Attachment 2-4-3(E): Material Investments, submitted as part of this Application on February 10, 2020. The Corrective Renewal expenditure has gradually increased from 2015 to 2018 and decreased in 2019.

INTERROGATORY RESPONSE - CCC-50

CCC-50

EXHIBIT REFERENCE:

Ex. 2-4-3, p. 195, Table 6.13

SUBJECT AREA: Distribution System Plan

Has Hydro Ottawa revised any of its Maintenance activities or cycles since EB-2015-0004? If yes, please provide details.

RESPONSE:

Yes, the revisions Hydro Ottawa has made to its maintenance activities since its previous rebasing application[1] are listed below.

1. Annual visual transformer inspections are performed along with infrared scans.
2. Station tap changer maintenance cycles now vary depending on the type of tap changer, rather than being performed every 3-5 years along with transformer maintenance.
3. Underground vault inspections are now performed every 3-6 years.
4. XLPE cable testing is now performed annually.
5. Critical switch inspections are now performed every 8 years.
6. Insulator washing is now performed bi-annually.
7. Station switch inspections are now performed as part of the annual switchgear and breaker inspection.
8. Hydro Ottawa no longer performs preventative SCADA inspections. SCADA equipment is now inspected during troubleshooting when issues arise.
9. Relay maintenance is now included in Hydro Ottawa's switchgear and breaker maintenance program.

[1] Hydro Ottawa Limited, *2016-2020 Custom Incentive Rate-Setting Distribution Rate Application*, EB-2015-0004 (April 29, 2015).

10. Transformer Doble testing is now included in Hydro Ottawa's transformer maintenance program.
11. Vault maintenance was replaced by the vault inspection program. Maintenance is now performed reactively as-required.
12. Cable inspection is included in the new cable testing program.
13. Although it isn't listed in Table 6.13, graffiti abatement is still performed on pad mounted equipment as required.

Table 2.3.1 - Maintenance Programs, as submitted in Exhibit B-1-2: Distribution System Plan in EB-2015-0004, is included below for reference.

Table 2.3.1 - Maintenance Programs

	TIM Type	Cycle	Type
Substation	Station IR Scans	Annually	Predictive
	Switchgear Inspections	Annually	Preventative
	Breaker & Recloser	Every 4-6 Years	Preventative
	Station Switches	Annually	Preventative
	SCADA Inspections	Annually	Preventative /Predictive
	Relay	Every 4-6 Years	Preventative
	Station Inspections	Monthly	Predictive/Corrective
	Battery Maintenance	Annually	Predictive
	Transformer Maintenance	Every 3-5 Years	Preventative
	Transformer Doble	Every 3-5 Years	Predictive
	Transformer Oil Analysis	Annually	Predictive
	Transformer Tapchanger Maintenance	Every 3-5 Years	Preventative /Predictive
Distribution	Padmounted Switchgear IR and Visual	Every 3 Years	Predictive/Corrective
	Padmounted XFMR IR and Visual	Every 3 Years	Predictive/Corrective
	O/H IR Inspection	Every 3 Years	Predictive
	Vault Maintenance	Not Defined	All
	Vegetation Management	Every 2 or 3 Years	Preventative /Corrective
	Pole Inspection	Every 10 years	Predictive/Corrective
	Critical Switch Inspection	Every 3 Years	Preventative
	Insulator Washing	Annually	Preventative
	Switchgear CO_2 Washing	Every 3 Years	Preventative
	Cable Inspection	120 segments annually	Predictive
	Manhole Inspections	10 Year	Corrective
	Graffiti Abatement	Routinely	Corrective

INTERROGATORY RESPONSE - CCC-51

CCC-51

EXHIBIT REFERENCE:

Ex. 2-4-2 p. 274, Figure 8.3

SUBJECT AREA: Distribution System Plan

Figure 8.3 provides the Contribution to Total Forecast Expenditures by Drivers for the years 2021 to 2025:

a) Please explain what falls under System Capital Investment Support (14%);

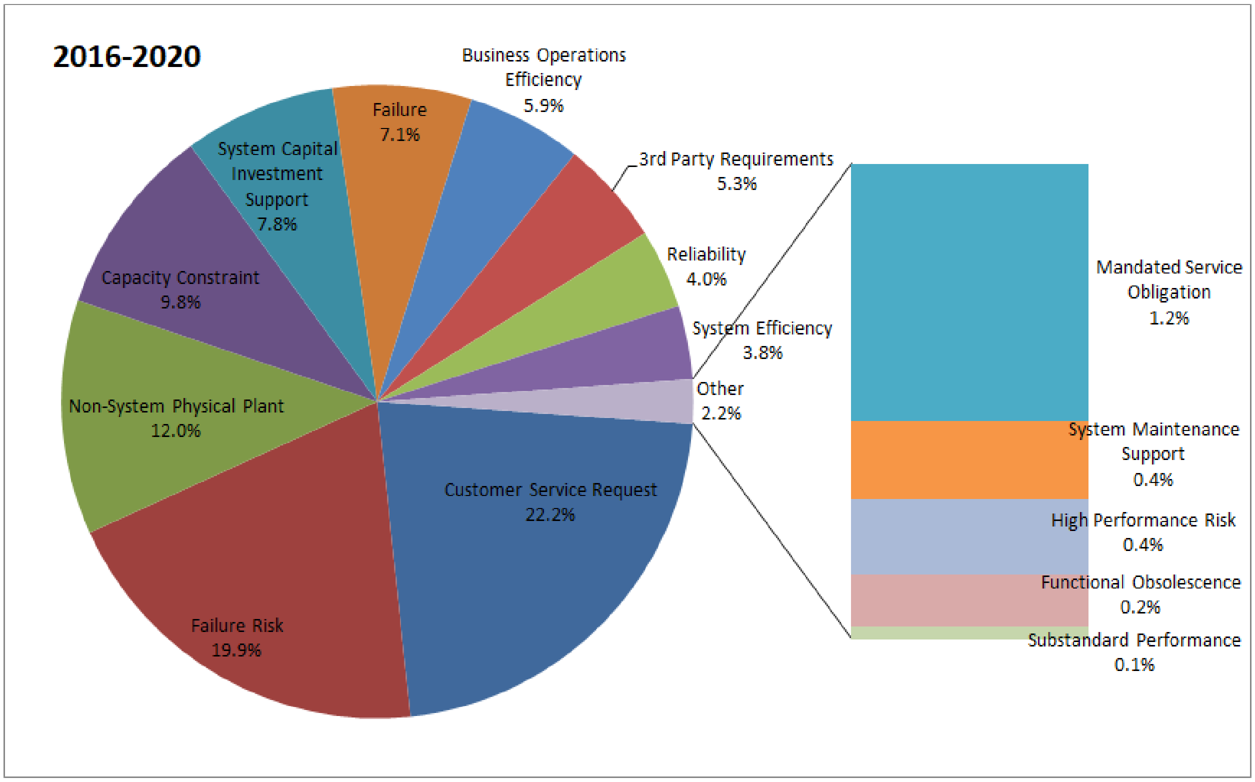
b) Please provide the same Figure for the years 2016 to 2020.

RESPONSE:

a) The following General Plant programs fall under the System Capital Investment Support Driver:
   - Fleet Replacement
   - Hydro One Payments

b) See Figure A below for 2016-2020 Contributions to Total Forecast Expenditures by Drivers.

1 **Figure A – 2016-2020 Contribution to Total Forecast Expenditures by Drivers**

2 

INTERROGATORY RESPONSE - CCC-52

CCC-52

EXHIBIT REFERENCE:

Ex. 2-4-3, p. 314, Table 8.22

SUBJECT AREA: Distribution System Plan

a) Please provide a version of Table 8.22 with the years 2016 to 2020 added to the Table.

b) Please provide an excel version of the Table.

RESPONSE:

a) Please see Attachment CCC-52(A): 2016-2025 System Renewal Forecast Expenditure by Program.

b) Please see the response to part (a) above.

INTERROGATORY RESPONSE - CCC-53

CCC-53

EXHIBIT REFERENCE:

Ex. 2-4-3

SUBJECT AREA: Distribution System Plan

Please complete the attached excel spreadsheet (CCC_IR_53) to provide Hydro Ottawa's Planned and Unplanned Asset Replacement Rates.

RESPONSE:

Hydro Ottawa does not currently track the information at the level CCC is requesting in its excel spreadsheet. However, please refer to Attachment 2-4-3(E): Material Investments to find Historical and Approved Units Replaced for each asset type. Table A below maps where in Attachment: 2-4-3(E) each of these can be found.

Table A – List of Historical and Approved Units Replaced by Asset Type

Type	Asset	Location
Station Assets	Station Transformer	Attachment 2-4-3(E), pages 1-16
	Station Switchgear	Attachment 2-4-3(E), pages 17-36
	Station P&C	Attachment 2-4-3(E), pages 37-51
	Station Battery	Attachment 2-4-3(E), pages 52-54
	Station Minor Asset	Attachment 2-4-3(E), pages 54-55
	Station Major Rebuild	Attachment 2-4-3(E), pages 55-69
Overhead Assets	Pole Renewal	Attachment 2-4-3(E), pages 70-83
	Overhead Switch / Recloser Renewal	Attachment 2-4-3(E), pages 84-98
Underground Assets	Vault Renewal	Attachment 2-4-3(E), pages 99-109
	Civil Renewal	Attachment 2-4-3(E), pages 110-123
	Cable Replacement	Attachment 2-4-3(E), pages 124-142
	Underground Switchgear Renewal	Attachment 2-4-3(E), pages 143-156
Corrective Renewal	Emergency and Critical Renewal	Attachment 2-4-3(E), pages 157-166
	Damage to Plant	Attachment 2-4-3(E), pages 167-168
Metering Renewal	Metering Upgrades	Attachment 2-4-3(E), pages 169-217

INTERROGATORY RESPONSE - CCC-54

CCC-54

EXHIBIT REFERENCE:

Ex. 2-4-3

SUBJECT AREA: Distribution System Plan

Please complete the attached excel spreadsheet (CCC_IR_54) to provide Hydro Ottawa's Asset Failure Rates by Asset Type.

RESPONSE:

The Failure Rate per Planned Replacement Level from 2018-2068 is provided for each asset type in the following sections of Attachment 2-4-3(E): Material Investments:

- Section 1.1 Station Asset Renewal
- Section 1.2 OH Distribution Renewal
- Section 1.3 UG Distribution Renewal

See Table A below for the specific locations within Attachment 2-4-3(E) where information by asset type can be found.

Table A – Asset Failure Rates by Asset Type - Mapped to Attachment 2-4-3(E): Material Investments

Type	Asset	Location
Station Assets	Station Transformer	Attachment 2-4-3(E), pages 1-16
	Station Switchgear	Attachment 2-4-3(E), pages 17-36
	Station P&C	Attachment 2-4-3(E), pages 37-51
	Station Battery	Attachment 2-4-3(E), pages 52-54
	Station Minor Asset	Attachment 2-4-3(E), pages 55-54
	Station Major Rebuild	Attachment 2-4-3(E), pages 55-69
Overhead Assets	Pole Renewal	Attachment 2-4-3(E), pages 70-83
	Overhead switch / Recloser Renewal	Attachment 2-4-3(E), pages 84-98
Underground Assets	Vault Renewal	Attachment 2-4-3(E), pages 99-109
	Civil Renewal	Attachment 2-4-3(E), pages 110-123
	Cable Replacement	Attachment 2-4-3(E), pages 124-142
	Underground Switchgear Renewal	Attachment 2-4-3(E), pages 143-156

INTERROGATORY RESPONSE - CCC-55

CCC-55

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment E, p. 168

SUBJECT AREA:

Hydro Ottawa's Corrective Renewal Program consists of three Budget Programs: Emergency Renewal, Critical Renewal, and Damage to Plant. With respect to Damage to Plant, Hydro Ottawa provides the number of units for each of the years 2016 to 2025 at Table 1.83 and the Historical Damage to Plant Contribution by Asset Type in Figure 1.83.

a) Please provide the same data for Emergency Renewal and Critical Renewal.

b) Please provide the same data for Plant Failure for the years 2015 to 2017.

RESPONSE:

a) Please see Table A below for the number of units replaced under Plant Failure, Emergency Renewal, and Critical Renewal. For Emergency Renewal and Critical Renewal from 2015-2025, refer to Table 1.78 in Attachment 2-4-3(E): Material Investments.

Table A – Number of Units Replaced under Plant Failure, Emergency Renewal & Critical Renewal

Programs	2015	2016	2017	2018	2019
Plant Failure	439	524	698		
Emergency Renewal				862	756
Critical Renewal				436	465

The Historical Emergency Renewal and Critical Renewal Contributions by Asset Type are shown in Figures A and B below.

Figure A – Historical Emergency Renewal Contribution by Asset Type (2018-2019)

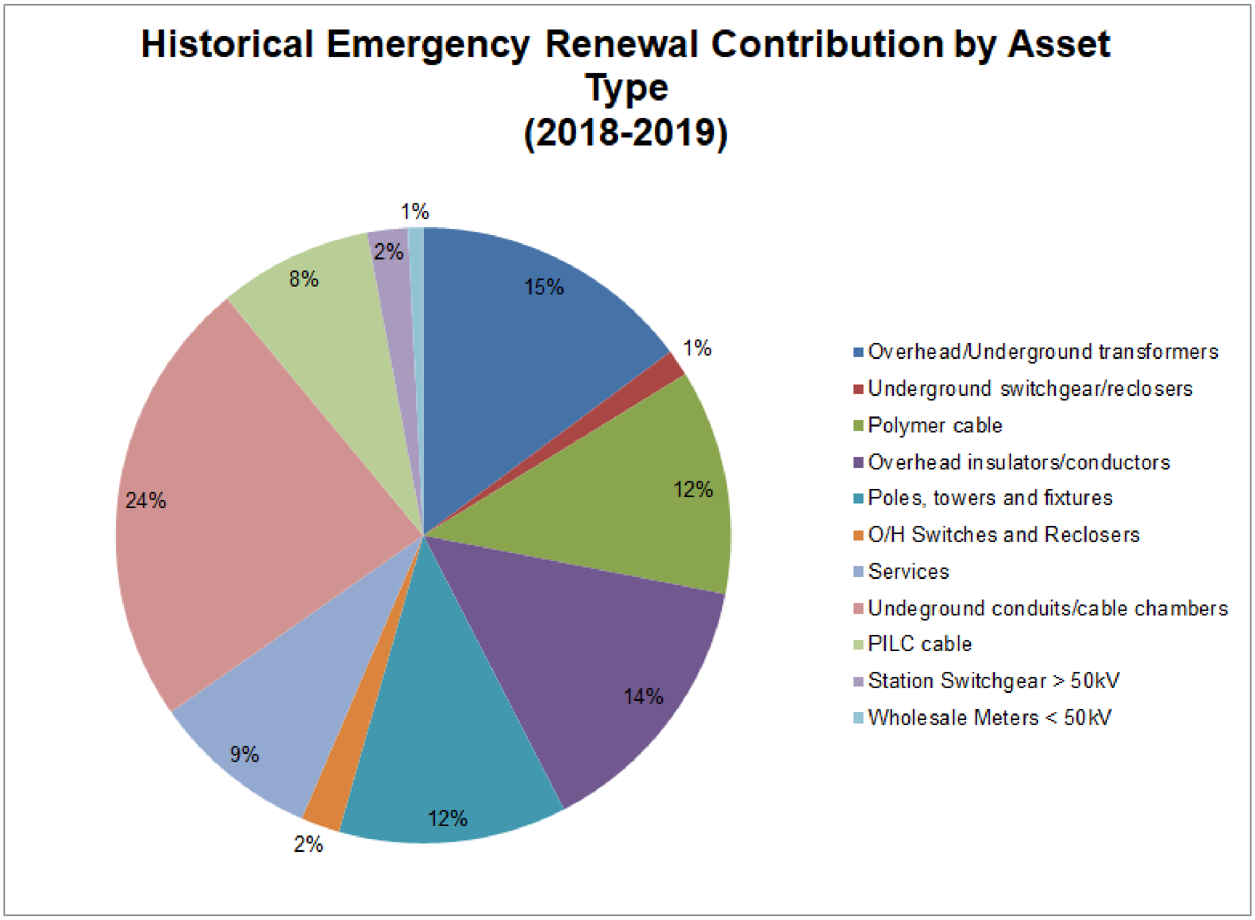
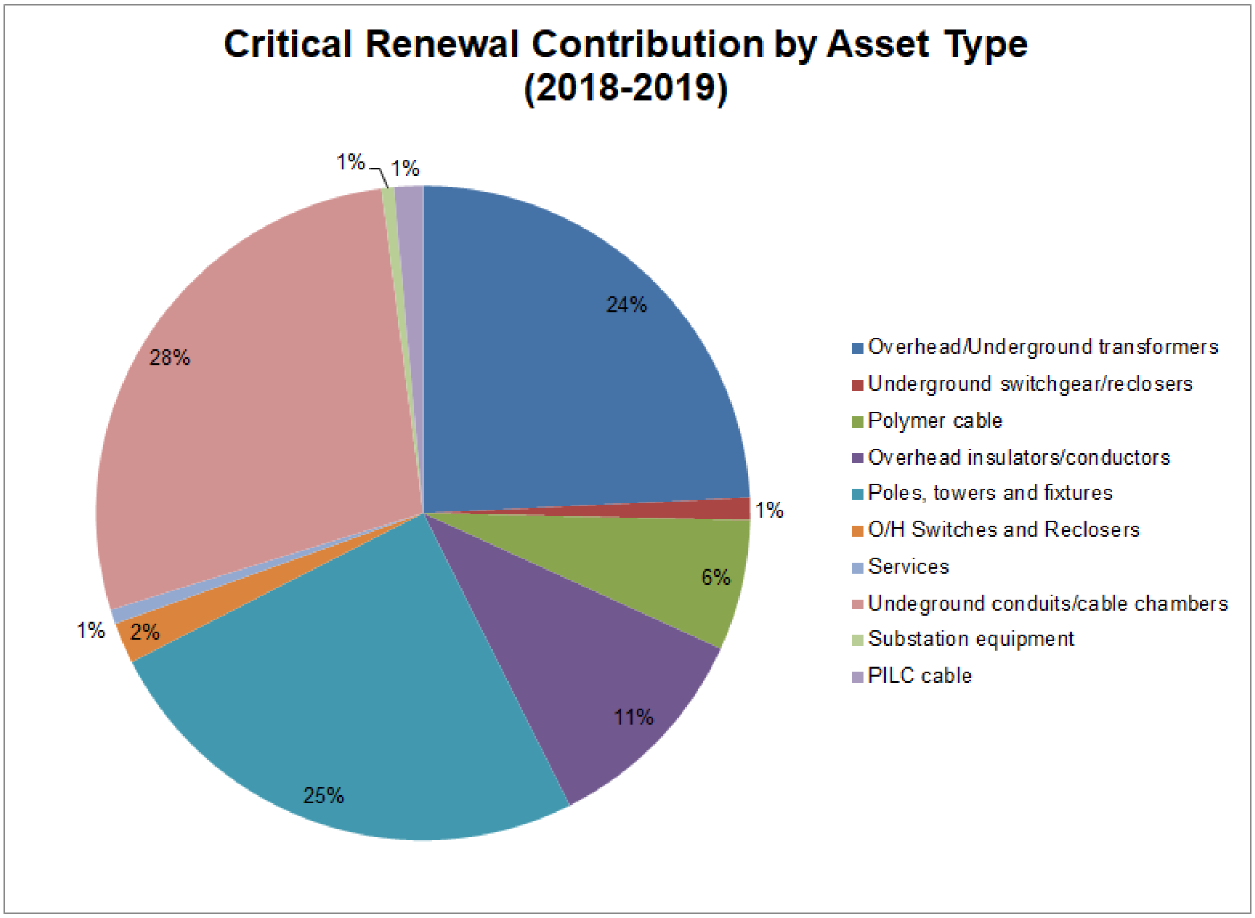
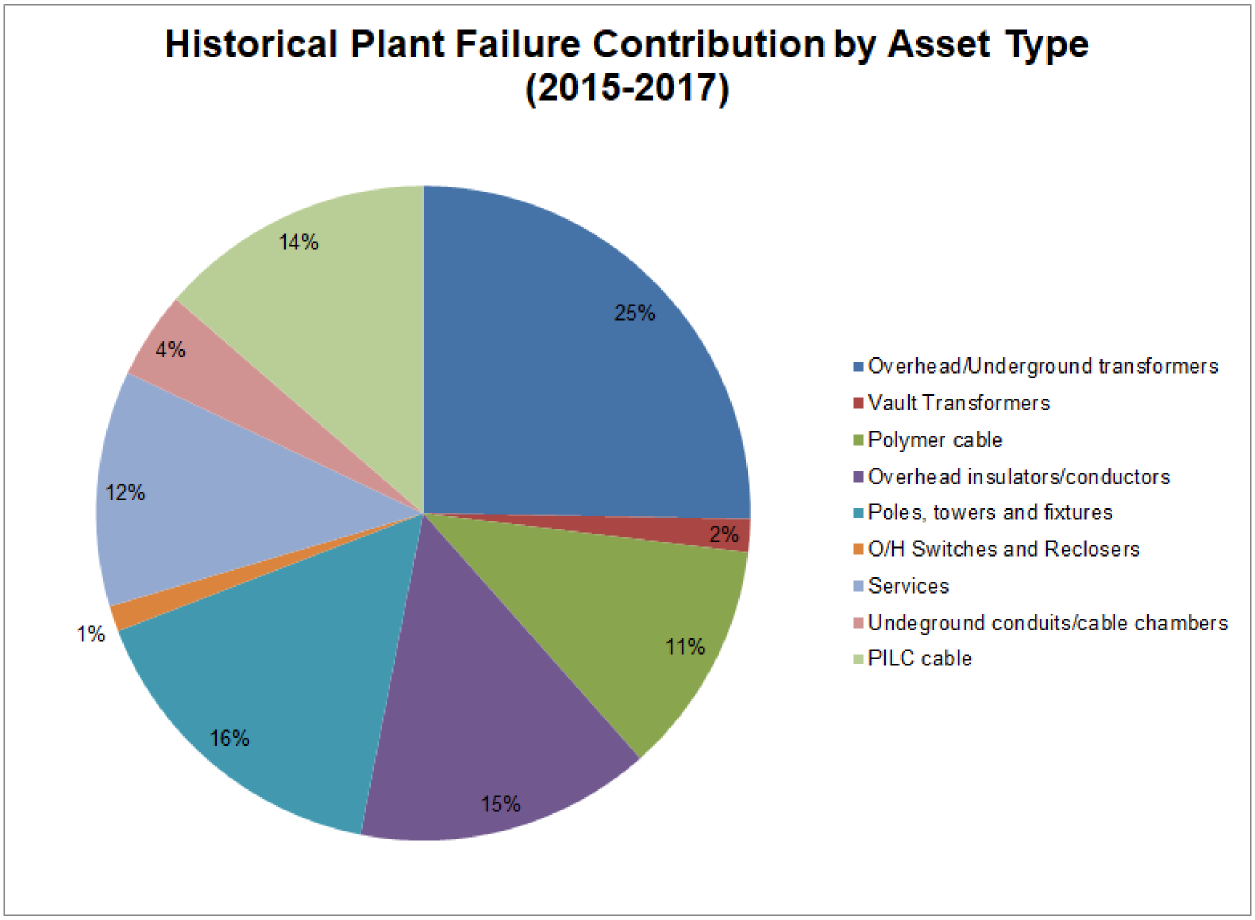


Figure B – Historical Critical Renewal Contribution by Asset Type (2018-2019)



b) For 2015-2025 Plant Failure, please refer to Table 1.78 in Attachment 2-4-3(E): Material Investments. Historical Plant Failure Contribution by Asset Type for 2015-2017 is shown in Figure C below.

Figure C – Historical Plant Failure Contribution by Asset Type (2015-2017)



INTERROGATORY RESPONSE - CCC-56

CCC-56

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M

SUBJECT AREA: Distribution System Plan

a) Please provide the terms of Reference for the Metsco's Review of Hydro Ottawa's Asset Condition Assessment Framework.

b) When was Metsco first requested by Hydro Ottawa to review their asset condition assessment (ACA) framework?

c) Please provide the final schedule of when the scope of work was completed.

d) Please provide the date of the Metsco Review letter Attachment M.

e) Was this work subject to an RFP process?

RESPONSE:

a) Due to the limited scope of work of the review, there were no set Terms of Reference for Metsco's review of Hydro Ottawa's Asset Condition Assessment Framework. Attachment CCC-56(A): Metsco Proposal - Asset Condition Assessment Third Party Review defines the project scope and work plan for Metsco's proposed review of the utility's Asset Condition Assessment ("ACA"), which ultimately culminated in the preparation of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

b) Metsco was first requested by Hydro Ottawa to review the utility's ACA framework in January 2019.

c) The Metsco review was first requested by Hydro Ottawa in January 2019.The final report of the review was completed May 2019. A second review was requested following the implementation of initial recommendations. This latter review led to the preparation of the report appended as Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

d) Attachment 2-4-3(M) is dated October 11, 2019.

e) No, this work was not subject to an RFP process.

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August 29th, 2019

Mark Wojdan
Supervisor, Maintenance & Reliability
Hydro Ottawa Ltd.

Dear Mark:

Re: Review & Validation of Updates to Hydro Ottawa's ACA Framework

As requested, METSCO Energy Solutions ("METSCO") is happy to offer their services to Hydro Ottawa Limited ("Hydro Ottawa") to support the review and validation of recent updates implemented to their ACA Framework.

Following the completion of METSCO's assessment of Hydro Ottawa's ACA framework, which resulted in the production of a report which highlighted the key findings, conclusions and recommendations from the assessment, Hydro Ottawa has spent the last five months updating their ACA framework accordingly as part of continuous improvements in order to rectify any issues or concerns and in order to ensure that the most accurate ACA results are being produced.

Due to these changes, there is a need for METSCO to review and validate these recent changes, and to issue a new post-analysis finding that will acknowledge these recent changes and provide indication into how these changes have allowed for continuous improvement to Hydro Ottawa's overall ACA framework.

Therefore, this initiative will include the review of Hydro Ottawa's recently updated ACA framework, along with a review of recent changes made to the framework, and overall validation that the changes have resulted in necessary continuous improvements and more accurate ACA outputs. The final deliverable will consist of a summarized expert statement that can be easily integrated as part of Hydro Ottawa's electricity distribution rate (EDR) filing application materials.

Project Scope:

- Review of the change log provided by Hydro Ottawa, which summarizes all changes implemented to the ACA framework, along with cross-referencing and comparison of changes to original findings from METSCO's ACA assessment to verify and validate if improvements have been introduced.
- Review and validation of the ACA framework and results, including:
  - Input data used in the ACA framework,
  - The ACA framework itself, including underlying mechanics, formulas and calculations, and,
  - The produced HI results from the framework.
- Documentation of all findings, validation results and conclusions, with cross-referencing to original ACA assessment findings.
- Integration of documented results into summarized expert statement that discusses the recent changes implemented by Hydro Ottawa as part of their ACA framework.

Work Plan & Schedule:

Work will commence immediately upon Hydro Ottawa's approval for project start. We are proposing to start the project on August 30th, 2019. The proposed schedule and milestones are defined below:

- Review of Provided Change Log by Hydro Ottawa and cross-referencing to original ACA Assessment recommendations: August 30th, 2019 – September 6th, 2019 (1 week)
- Review and validation of the data provided by Hydro Ottawa, including the input data, ACA framework and HI results: September 9th, 2019 – September 27th, 2019 (3 weeks)
- Documentation of findings, validation results and conclusions with cross-referencing to original recommendations from ACA assessment: September 30th – October 4th, 2019 (1 week)
- Production of Draft Summarized Expert Statement for Hydro Ottawa: September 30th – October 4th, 2019 (1 week)
- Review and Finalization of Summarized Expert Statement: October 7th, 2019 – October 18th, 2019 (2 weeks)

Adress:
METSCO Energy Solutions
#215; 2550 Matheson Blvd. E,
Mississauga, ON, L4W 4Z1

Call:
Phone: 905–232–7300
Fax: 905–232–7405

On-line:
Email: info@metsco.ca
Website: metsco.ca

Throughout the course of the project, there will be regular communications between METSCO and Hydro Ottawa to ensure that all milestones and the overall schedule remains on track.

Project Costs:

METSCO will complete this initiative for a fixed cost of $17,000 CAD.

We look forward to assisting with this important assignment for Hydro Ottawa Ltd.

Yours Truly,

Robert Otal
Director of Asset Management & Analytics

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metsco.ca

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Email: robert.otal@metsco.ca

INTERROGATORY RESPONSE - CCC-57

CCC-57

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M

SUBJECT AREA: Distribution System Plan

Metsco's review indicates Hydro Ottawa is constantly striving for continuous improvements, and in this regard, they continue to enhance and evolve their ACA framework and associated business processes. This includes efforts to transition from manual to automated procedures with respect to ingesting input data, including inspection, testing and monitoring data, in order to process health index results in a turn-key manner, and with an eventual goal to store this data into enterprise systems, such that the results can be better integrated into other planning procedures. Hydro Ottawa has established an implementation roadmap in order to achieve a desired end-state such that ACA results are available in a common, auditable, accessible and convertible format.

a) In terms of completeness, what score out of 100% would Metsco give Hydro Ottawa with respect to this goal and implementation of the roadmap.

b) In terms of the maturity of Hydro Ottawa's ACA framework, how would Metsco describe Hydro Ottawa?

RESPONSE:

a) In terms of completeness, Metsco has not provided Hydro Ottawa with a score with respect to this goal and implementation of the roadmap.

b) In terms of maturity of Hydro Ottawa's ACA framework, please refer to Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review, which was submitted as a part of this Application on February 10, 2020.

INTERROGATORY RESPONSE - CCC-58

CCC-58

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M, p. 1

SUBJECT AREA:

Metsco reviewed Hydro Ottawa's Overarching Processes, Systems & Associated Input Data. Hydro Ottawa currently uses Microsoft Excel to store the associated input data and perform the necessary calculations to produce the desired HI results.

a) Did Metsco undertake a detailed review of Hydro Ottawa's input data? Please explain.

b) Does Metsco have any concerns or recommendations regarding data quality with respect to completeness, accuracy, consistency, and availability?

c) Did Metsco undertake a detailed review of Hydro Ottawa's Microsoft Excel process? Please explain.

d) Does Metsco have any concerns or recommendations regarding the manual excel process, calculations, results and how they are currently integrated into the planning process and used to derive capital budgets?

RESPONSE:

a) Yes, Metsco undertook a detailed review of Hydro Ottawa's input data. Metsco reviewed the procedures and processes dedicated to collecting the data and provided comments and recommendations. For further details, please refer to the response to interrogatory CCC-60.

b) Yes, Metsco provided Hydro Ottawa with recommendations regarding data quality with respect to completeness and availability.

c) Yes, Metsco undertook a detailed review of Hydro Ottawa's Microsoft Excel process. Please refer to page 2 of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

d) Yes, Metsco provided Hydro Ottawa with comments and recommendations regarding the manual excel process, calculations, results and how they are currently integrated into the planning process and used to derive capital budgets. For further detail, please refer to page 2 of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

INTERROGATORY RESPONSE - CCC-59

CCC-59

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M, p. 2

SUBJECT AREA: Distribution System Plan

Metsco reviewed the asset-class HI formulations, including the produced results and sample sizes.

a) Does Metsco have any concerns or recommendations regarding current asset-class HI formulations and results for any specific asset class?

b) Does Metsco have any concerns or recommendations regarding asset sample sizes?

c) Does Metsco have any concerns or recommendations regarding the current ACA output?

RESPONSE:

a) Yes, Metsco provided Hydro Ottawa with their recommendations regarding current asset-class HI formulations and results for specific asset classes. Hydro Ottawa undertook steps to address the recommendations provided in the May 2019 initial assessment and subsequently retained Metsco to conduct a follow-up assessment in August 2019. A summary of the results of the follow-up assessment can be found on page 2 Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review. Please note that pages 2-4 of Attachment 2-4-3(M) are erroneously labeled as Attachment G.

b) Yes, Metsco provided Hydro Ottawa with their recommendations regarding asset sample sizes. Hydro Ottawa undertook steps to address the recommendations provided in the May 2019 initial assessment and subsequently retained Metsco to conduct a follow-up assessment in August 2019. A summary of the results of the follow-up assessment can be found on page 2 of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

c) Yes, Metsco provided Hydro Ottawa their recommendations regarding the current ACA output. Hydro Ottawa undertook steps to address the recommendations provided in the May 2019 initial assessment and subsequently retained Metsco to conduct a follow-up assessment in August 2019. A summary of the results of the follow-up assessment can be found in Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.

INTERROGATORY RESPONSE - CCC-60

CCC-60

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M, p. 2

SUBJECT AREA: Distribution System Plan

Hydro Ottawa has implemented a number of enhancements to the ACA framework since METSCO's initial assessment was performed. When was Metsco's initial assessment performed? Please provide the initial assessment document.

RESPONSE:

Metsco's initial assessment was performed in May 2019. See Attachment CCC-60(A): Hydro Ottawa ACA Review - Initial Assessment for a copy of the initial assessment document. Please also refer to Attachment CCC-60(B): Hydro Ottawa ACA Review - Follow Up Assessment for a copy of the follow-up assessment dated October 2019.

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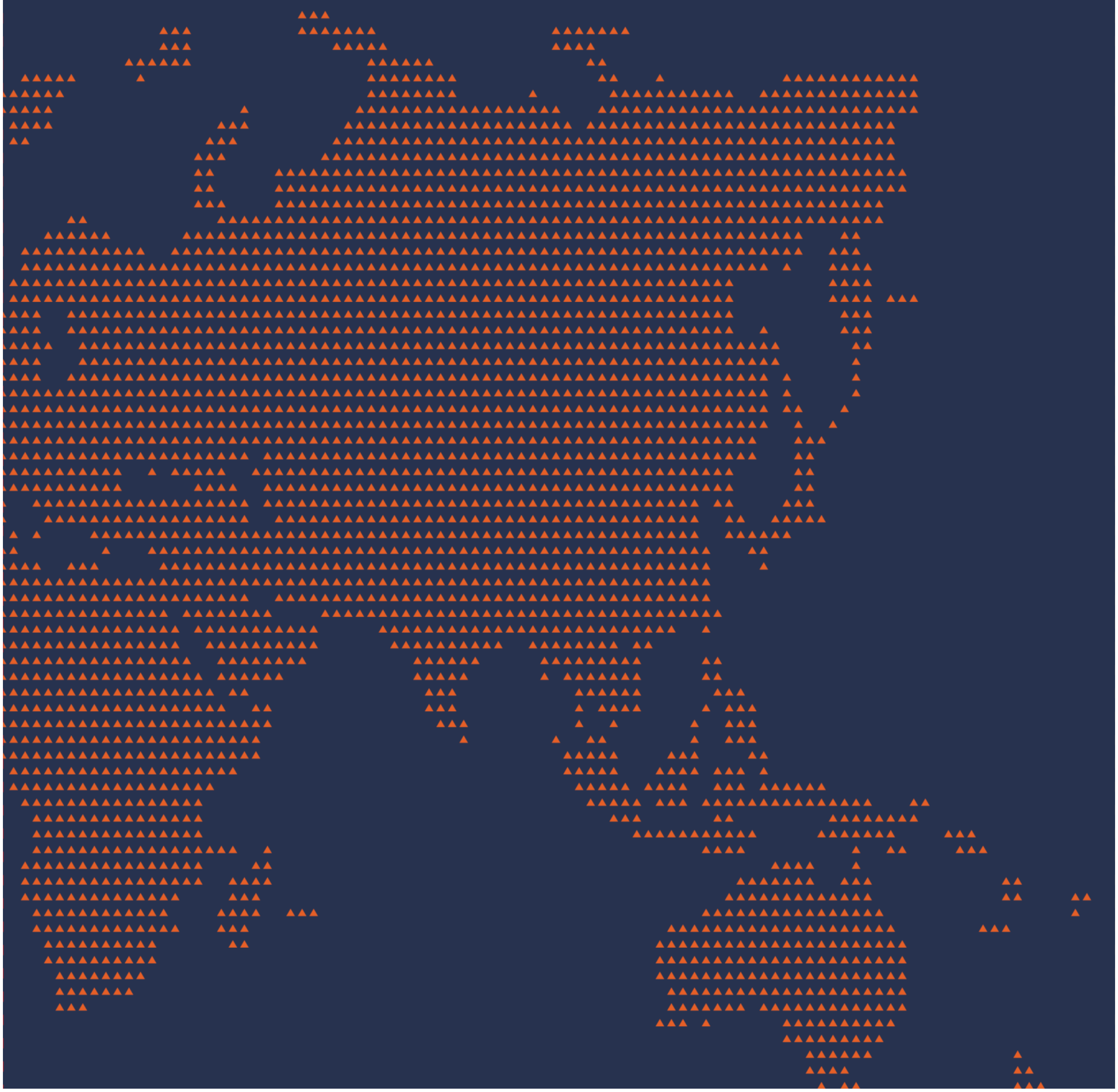

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May 2019 - PRIVILEGED & CONFIDENTIAL
Review of Hydro Ottawa's ACA Framework

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Review of Hydro Ottawa's Asset Condition Assessment (ACA) Framework

FINAL Report & Conclusions

PRIVILEGED & CONFIDENTIAL

Prepared For:

Hydro Ottawa Limited

Prepared By:

METSCO Energy Solutions Inc.
#215, 2550 Matheson Blvd East
Mississauga, ON L4W 4Z1

Disclaimer

This report has been prepared by METSCO Energy Solutions Inc. ("METSCO") for Hydro Ottawa Limited ("Hydro Ottawa"). Neither METSCO, nor any other person acting on its behalf makes any warranty, express or implied, or assumes any legal responsibility for the accuracy of any information or for the completeness or usefulness of any process disclosed or results presented, or accepts liability for the use, or damages resulting from the use, thereof. Any reference in this report to any specific process or service by trade name, trademark, manufacturer or otherwise does not necessarily constitute or imply its endorsement or recommendation by METSCO.

Review of Hydro Ottawa's ACA Framework

Final Report

May 2019

Experts:

Robert Otal, B.Eng., P.Eng.
Director, Asset Management & Analytics

Dawid Lizak, B.A.Sc., M.Eng
Associate, Asset Management & Strategy

Approved By:

Babak Jamali, P.Eng
Chief Operating Officer

Definitions

The following definitions are used with respect to the evaluation of Hydro Ottawa's asset condition assessment (ACA) framework:

Maintenance: Consists of various tasks, including visual inspections, testing and repairs to assets in order to keep the asset operating within the appropriate condition such that it reaches its projected useful life.

Asset Condition Assessment: Refers to an approach/framework used to quantify the condition grading of the asset which relies upon inspection and testing data.

Condition Score: A condition score is an assigned grade to the applicable states of the degradation factors. Condition scores ranges from A to E or in the corresponding numerical terms 4 to 0. A or 4 corresponds to the states which indicates the best condition for the degradation factor, while E or 0 corresponds to the worse condition.

Degradation Factors: Degradation factors are defined as the conditions which affect asset health. Degradation Factors are selected from the inspection fields which are applicable for the determination of asset health. Each degradation factor will be given a weight which corresponds to the amount of contribution towards asset failure.

Input Data: For the purpose of this discussion, input data represents the inspection, testing and monitoring data that is captured from the field in order to support the asset condition assessment framework and the calculation of the Health Index result.

Health Index (HI): The Health Index represents the quantified condition score of the evaluated asset, taking into consideration weighted degradation factors which contribute to the overall failure of the asset.

Health Index Maturity: The Health Index Maturity is used to determine the current state of a utility with respect to the development of a health index. This scale has been developed utilizing METSCO internal engineering experience and consultations performed for other utilities. A utility can be ranked within 4 levels of Health Index Maturity based upon the quality and availability of data:

HI Maturity	Maturity Definition
1	No Data is available for the use in developing an HI score. Data collection initiatives are required before an HI can be adopted for use.
2	Sufficient data is available for developing an HI. However, the age index will carry a greater weight when compared to the other degradation factors, due to data availability. Additional data collection processes must be executed such that all degradation factors are equally utilized.
3	Full datasets are available to adopt an HI that utilizes and supports all degradation factors. Additional data collection is still required to adopt an "Ideal" industry-standard HI.
4	Maximum datasets are available to adopt the industry-standard ideal HI framework

Table A-0-I Health Index Maturity Definitions

Sample Size: The Sample Size with respect to this document is defined as the number of assets in each asset class for which the Health Index can be used to calculate a health index score. In all cases, sample size needs to be maximized as much as possible while maintaining or improving accuracy of the HI output. Equation A-1 presents the formula used for the calculation of sample size percentage.

$$Sample\ Size = \frac{FS}{Pop} \times 100\% \qquad \textbf{(Equation A-1)}$$

Where:

- FS is defined as the number of assets within an asset class that has a full set of HI data that can be used for the calculation of the health index.
- Pop is defined as the total population of assets within an asset class that are In-Service.

Executive Summary

Hydro Ottawa's asset condition assessment (ACA) framework represents an integral component as part of its broader asset management (AM) framework, to proactively manage its fleet of distribution assets and ensure that the right actions are undertaken to the right assets at the right time. This framework leverages information captured from maintenance programs, creating an essential linkage between the ongoing maintenance activities and the capital investment decision-making. From these efforts, asset investment can be further diversified with localized information indicating actual degradation of the assets in the field. There are also further opportunities, in turn, to enhance maintenance programs and introduce data enhancements.

METSCO decided to undertake this assignment as per the following three stages: (a) review of the overarching processes, systems and associated input data that are supporting the ACA framework, (b) review of the asset-class HI formulations, including the produced results and sample sizes, and (c) review of the end-state applications produced by the ACA framework, including how the HI results are ultimately integrated into broader AM deliverables. From these assessments, a number of conclusions and recommendations can be established in order to further improve upon Hydro Ottawa's ACA framework moving into the future.

Review of the overarching processes, systems and associated input data provided indication that Hydro Ottawa's ACA framework is well integrated within the broader AM process – albeit with manual processes required to ingest input data and transfer outputs – the health index results – into other AM-related processes, procedures and outcomes. Hydro Ottawa has developed detailed and robust documentation both for the ACA framework itself, including the underlying health index formulations, as well as for the underlying maintenance programs that supply inputs to the ACA framework. In particular, documentation for the Overhead Line Inspection was found to be the most detailed, and it is strongly recommended that Hydro Ottawa expand this level of detail across all of their major asset classes.

When reviewing the health index formulation, a deviation with respect to the condition category ranges was identified for substation assets, in which Very Good assets are defined as being within the 90-100 range, and Good assets are defined as being within the 70-90 range, which effectively expands the range of the "Good" category while reducing the range of the "Very Good" category. This deviation was not found within the supporting documentation on the ACA framework as provided by Hydro Ottawa subject-matter experts, and is only applied to substation assets and not to distribution assets, which utilize the industry-standard Good range of 70-85 and Very Good range of 85-100. Further analysis has concluded that this deviation introduces a very minimal impact for overall

results. In general, however, it is recommended that Hydro Ottawa consider a common range of health index categories across all asset classes.

Currently, while health index results are ultimately integrated within Hydro Ottawa's Copperleaf C55 AIP system, health index formulations and associated input data continue to be managed within a series of Microsoft Excel files. A number of calculation errors were identified during the course of the investigation that were largely due to the open nature of the Excel platform. Further integration of the ACA framework – including formulas and inputs - within a more automated, controlled and stable enterprise environment would ultimately reduce the possibility of calculation-related errors and ensure that the HI results are produced in the most consistent manner possible.

It is recommended that Hydro Ottawa establish a common strategy between stations and distribution assets when it comes to missing data. Currently, distribution assets that are missing specific data inputs will be marked as "unknown", and automatically assigned the highest HI grade value, regardless of the actual performance and condition of the assets in field. While this approach certainly increases the sample size of the assets that can be evaluated, it can also mask serious deficiencies within the system. For stations assets, Hydro Ottawa applies a different approach where a particular factor will be removed from the formulation if underlying data is missing. In these cases, a health index calculation can still be undertaken where overall available data exceeds 70%. As per this approach, six of the eight station asset classes were found to have a sample size below 50%, whereas all distribution asset classes receive a sample size of 100% respectively. Ultimately, we believe that the stations approach to HI calculation is a more optimal approach, as it allows for data gaps to be highlighted and those affected assets to be targeted for enhanced data collection activities, whereas the approach for distribution assets appears to mask data gap deficiencies by inflating the sample sizes of the asset classes.

On an overall whole, Hydro Ottawwa's HI formulations were found to be exactly or closely aligned with the best practices with respect to the degradation of assets, and have therefore achieved a Stage 4 level of maturity. However, when considering the nature of the calculation, the process in which the HI results are calculated, and data gaps that may impede the ability to capture accurate results, Hydro Ottawa's overall ACA framework would possess a maturity level of 3.

It is recommended that Hydro Ottawa continue to work on mitigating the existing data gaps, such that sample sizes can be improved and outputs can be fully enhanced. Further integration and automation of the ACA framework would create a seamless architecture whereby data gaps are readily identified and mitigated, resulting in continuous improvement to HI results, and ultimately allowing Hydro Ottawa to take the right actions to the right assets at the right time.

Table of Contents

1 Introduction

Hydro Ottawa's asset condition assessment (ACA) framework represents an integral component as part of its broader asset management (AM) framework, to proactively manage its fleet of distribution assets and ensure that the right actions are undertaken to the right assets at the right time.

An asset condition assessment framework takes into consideration information captured via maintenance programs, including visual inspection and testing data results, along with monitoring data that is automatically captured via supervisory control & data acquisition (SCADA) and advanced distribution management system (ADMS) platforms. This input data can be leveraged in order to quantify a weighted condition score – also known as the health index (HI) for each individual asset. The health index, which is normalized on a scale from 0 (very poor) to 100 (very good) provides indication into the overall health of the evaluated asset based upon weighted degradation factors which contribute towards the overall probability of failure of the asset.

The health index results ultimately add another layer of information apart from the assets' age, thereby further diversifying prioritization and overall decision-making for the utility. Health index results can also be converted into a condition-based failure probability result as part of a broader risk-based asset management framework, in order to identify those assets that are experiencing an accelerated form of degradation.

In 2015, METSCO provided Hydro Ottawa with a new methodology for evaluating asset health by developing probability of failure curves and recommending the implementation of new health index formulations. Hydro Ottawa has subsequently retained METSCO to evaluate their implementation of the provided ACA guideline and HI methodologies, and identify areas of improvement.

METSCO decided to undertake this assignment as per the following three stages: (a) review of the overarching processes, systems and associated input data that are supporting the ACA framework, (b) review of the asset-class HI formulations, including the produced results and sample sizes, and (c) review of the end-state applications produced by the ACA framework, including how the HI results are ultimately integrated into broader AM deliverables. The subsequent chapters within this report are therefore aligned to the assessment stages as described above.

Chapter 2 of this report provides results from the assessment and recommendations for the overarching ACA framework and underlying processes that are used to capture necessary input data, calculate HI scores, integrate the scores into the broader AM procedures, and continually improve upon the HI scoring and AM-related decision-making.

Chapter 3 of this report provides results from the in-depth assessment that was performed for Hydro Ottawa's health index results across the following major asset classes within the distribution system:

- Substation assets:
  - Power transformers
  - Transformer tap changers
  - High-Voltage (>44kV) Switchgear (SF_6 breakers, Circuit Switchers)
  - Medium-Voltage (<44kV) Switchgear (Vacuum, Oil, SF_6, Air-insulated breakers, Oil reclosers)

- Overhead distribution assets:
  - Wood poles
  - Gang-operated load-break switches (Manual, SCADA)
  - Pole-mounted overhead transformers
  - Line reclosers

- Underground distribution assets:
  - Underground cables (PILC, XLPE/TRXLPE/EPR)
  - Underground distribution transformers (Pad-mounted, vault)
  - Underground switches (Pad-mounted, vault)
  - Manholes

Finally, Chapter 4 provides results from the assessment of Hydro Ottawa's current-state applications of the ACA and health index results, as well as recommended improvement opportunities.

2 Review of Processes & Systems Supporting Hydro Ottawa's ACA Framework

The first stage of METSCO's assessment of Hydro Ottawa's ACA framework consisted of an evaluation of the overarching processes, systems and input data that serve to govern and support the overall delivery of the ACA and health index results for Hydro Ottawa's distribution system assets.

2.1 Interaction between ACA Framework and AM Process

A central framework is necessary to effectively support the accurate and consistent calculation of the health index results, and ensure their correct application within a broader AM process. Figure 2.1 illustrates Hydro Ottawa's broader AM process, with the Asset Condition Assessment component directly feeding into the Testing, Inspection & Maintenance Programs for the purposes of producing the eventual Risk Assessment results.

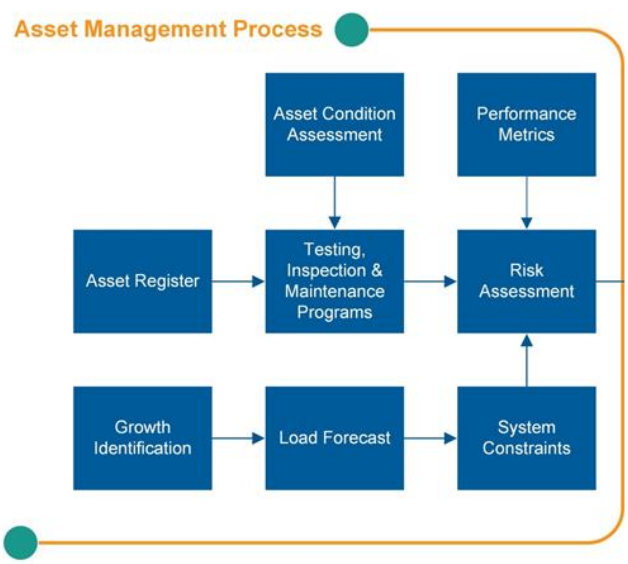

Figure 2.1 – Hydro Ottawa's Asset Management (AM) Process [1]

Figure 2.2 illustrates Hydro Ottawa's current ACA framework in further detail, providing insight into the inputs and outputs associated with this framework. In particular, data from testing, inspection & maintenance programs along with monitoring data as captured from Hydro Ottawa's SCADA systems are ingested and linked to weighted degradation factors that are contained within the health index formulations.

Each asset class/type, and in some cases sub-class/type, will have its own unique set of weighted degradation factors and subsequently a health index formulation. Therefore, it is necessary to capture the evaluated assets' type and/or sub-type data from the asset register in order to select the most appropriate formulation for that asset. The asset register also contains the age of the asset, which is utilized as a degradation factor within the formulations for all electrical distribution assets.

The key output from the ACA framework is the health index result, which is later used as part of Hydro Ottawa's risk assessment to support decision-making within the broader AM process.

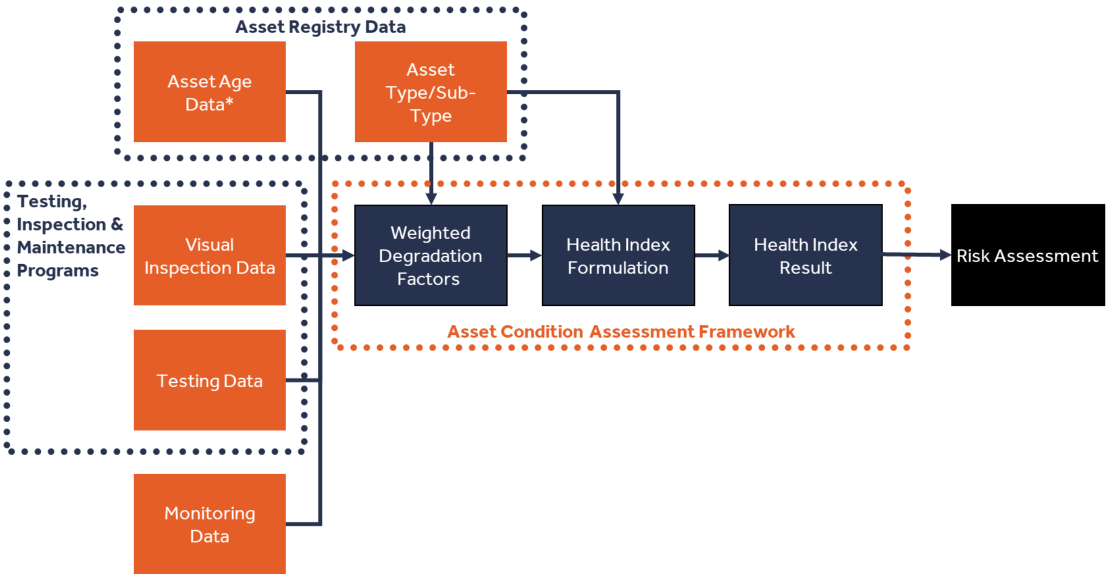

Figure 2.2 – Inputs & Outputs associated with ACA Framework

2.2 Applied Methodology within Hydro Ottawa's ACA Framework

Figure 2.3 further illustrates the anatomy of the health index calculation taking place within Hydro Ottawa's ACA framework. Hydro Ottawa has adopted an additive calculation approach, whereby a series of defined degradation factors are weighted in accordance to the overall failure probability of the asset in question. A letter grade will be assigned to each degradation factor based upon specific definitions that will vary from degradation factor to degradation factor, and will largely depend on the nature of the input data utilized. For instance, where visual inspection data represents the key input data supporting a given degradation factor, the letter grading definitions will be of a descriptive nature. Where testing data represents the key input data supporting a given degradation factor, the letter grading definitions will be defined as per a numerical range that corresponds to the testing results. A maximum five-point scale (i.e. A-E) is used for each degradation factor, although depending on the nature of the input data, two-point (i.e. A, E) or three-point (A, C, E) scales may be utilized instead.

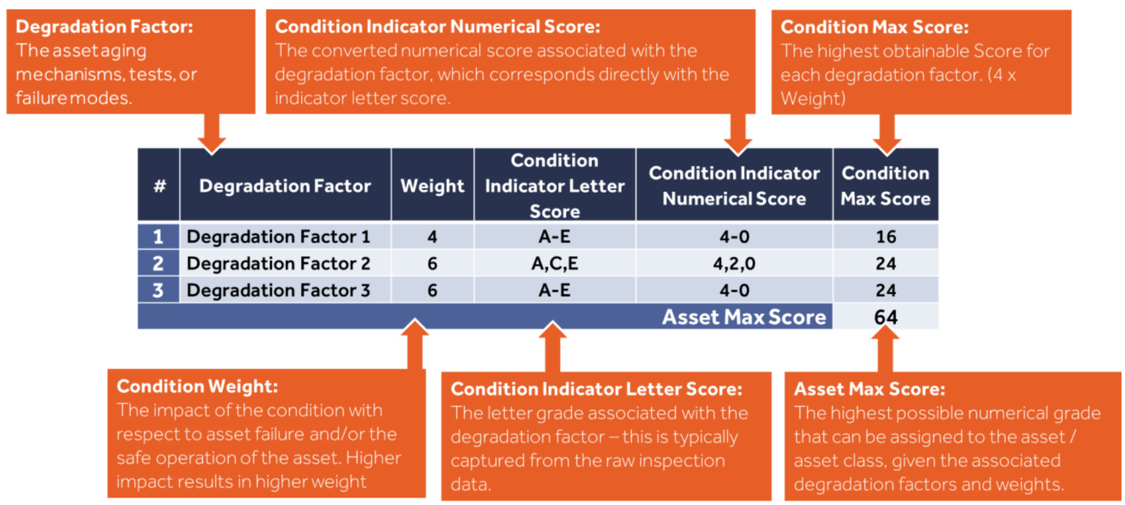

Figure 2.3 – Anatomy of Hydro Ottawa's Health Index Calculation

Each letter grade is converted into a numerical grade such that a health index value can be calculated. The letter grade of E is defined as the "worst" or lowest grade and corresponds to a numerical score of 0. The letter grade of A is defined as the "best" or highest grade and corresponds to a numerical score of 4. Typical definitions for each letter / numerical grade are defined in Figure 2.4.

Degradation Factor Indicator	Degradation Factor Criteria Description
A – 4	Best Condition; Characteristics of a brand new asset
B – 3	Normal Wear; Characteristics of a slightly aged asset
C – 2	Requires Remediation; Characteristics of an asset with signs of wear
D – 1	Rapidly Deteriorating; Characteristics of an asset with repairable damage
E – 0	Beyond Repair; Characteristics of an asset with non-repairable damage

Figure 2.4 – Typical definitions for Letter / Numerical Grades

The health index is then calculated by summing up each weighted degradation factor result and dividing this with the maximum possible score that the evaluated asset could receive, in order to normalize a condition score on a scale from 0 (very poor) to 100 (very good). This process is further detailed in Equation 1.

- $$HI = \left(\frac{\sum_{i=1} Weight_i \text{ x } Numerical\ Score_i}{Asset\ Max\ Score}\right) \text{ x } 100 \quad \text{(EQ 1)}$$

Figure 2.5 illustrates the typical definition and requirements for each of the health index condition grades from Very Poor up to Very Good.

Health Index	Condition	Description	Requirements
85–100	Very Good	Some ageing or minor deterioration of a limited number of components	Normal maintenance
70–85	Good	Significant deterioration of some components	Normal maintenance
50–70	Fair	Widespread significant deterioration or serious deterioration of specific components	Increase diagnostic testing; possible remedial work or replacement needed depending on criticality
30–50	Poor	Widespread serious deterioration	Start planning process to replace or rehabilitate considering risk and consequences of failure
0–30	Very Poor	Extensive serious deterioration	Asset has reached its end-of-life; immediately assess risk; replace or refurbish based on assessment

Figure 2.5 – Definitions & Requirements for each Health Index Condition Grade

It should be noted that for Hydro Ottawa's substation assets, there is a deviation from the category ranges, in which Very Good assets are defined as being within the 90-100 range, and Good assets are defined as being within the 70-90 range, which effectively expands the range of the "Good" category while reducing the range of the "Very Good" category. It should be noted that this deviation is not documented within any of Hydro Ottawa's supporting documentation, which is further detailed in Section 2.3. Due to this adjustment, there are technically different ranges in health index categories between substation and distribution assets. For example, a distribution asset that receives a score of 86 would be considered to be Very Good, yet if it were a substation asset, it would be considered as Good. Generally, it is recommended that a common health index range is applied to all assets, such that health index scores remain equivalent for all assets. If an adjustment to the ranges is absolutely necessary, then appropriately justification and documentation should be established to better explain these changes.

The additive model is capable of calculating a health index result even if not all input data to support each degradation factor is available. At least 70% of this data must be available in order for the health index result to be considered as "valid".

While additive models remain typical for the majority of utilities that have implemented an ACA framework, there are other more advanced models that may be considered as part of future improvements. For instance, many utilities are now utilizing gateway models in conjunction with additive models in order to compute a more dynamic grade for the evaluated assets. The gateway approach allows for further reduction of the health index grade if a given degradation factor has fallen below a certain letter/numerical grade. As an example, if the dissolved gas analysis (DGA) score reaches a result of E or 0, the entire health index should be divided by 2. Currently, Hydro Ottawa's ACA framework only considers the gateway approach for wood pole assets, where a poles' remaining strength between 31% – 60% results in a reduction of the health index result by half, and a remaining strength of 30% or less results in the wood pole automatically receiving a health index score of 0. It is recommended as part of incremental improvements that Hydro Ottawa consider the implementation of the gateway model (used in conjunction with the additive model) for other asset classes, including stations assets in particular.

2.3 Supporting Documentation & Training Programs for Hydro Ottawa's ACA Framework

The approach as described in Section 2.2 that is implemented within Hydro Ottawa's ACA framework has been documented within an "asset health index guideline" [1]. This document provides useful and centralized information concerning the scope of the ACA framework implementation, as well as the applied additive model methodology within this framework. The document then provides the detailed health index formulations for each asset class, including weights and definitions for each degradation factor. The document serves as a useful educational reference for employees being introduced to the ACA framework for the first time.

However, it should be noted that the guideline does not provide any documentation in regards to the deviation in the health index category ranges for Substation assets, where the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. This adjustment also has not been found in any other Hydro Ottawa documents that were provided during this exercise. As noted in Section 2.2, it is recommended that Hydro Ottawa consider a common set of health index category ranges between substation and distribution assets. It is also recommended that the ranges should be appropriately documented, and if a deviation in the ranges must be introduced, appropriate justification for the deviation should be established within the documentation.

For overhead and underground distribution assets, Hydro Ottawa has developed comprehensive working & inspection procedures in order to ensure that visual inspection results are derived as consistently as possible for each evaluated asset. These types of documents serve as necessary training tools to ensure that degradation factor grades and overall health index scores remain consistent from inspection to inspection, and from inspector to inspector.

The Overhead Line Inspection working procedure document was found to contain the greatest amount of detail, with images of wood poles and insulators associated to degradation factor grade levels. It should be noted, however, that this same level of detail was not found within the associated underground asset documents. Furthermore, there are currently no documents available to define the inspection processes and standards for substation assets.

Through discussions with Hydro Ottawa subject matter experts, it was determined that current-state documents are available for overhead and underground inspection procedures as these assets may be inspected via third-party agencies, and therefore there is a greater need to have available documentation to ensure that the proper procedures are followed and that the necessary quality control and assurance associated with these maintenance programs and the corresponding outputs are executed. At the same time, substation assets are entirely inspected via internal Hydro Ottawa field crew members, and therefore there is a lesser need to have these documents on hand.

From a continuous improvement perspective, it is recommended that Hydro Ottawa establish a series of inspection training documents for all asset classes. Ideally, these documents should contain the same level of detail, including photos for each degradation factor score, such that consistency can be established for visual inspection procedures and corresponding outputs.

2.4 Supporting Processes & Systems for Hydro Ottawa's ACA Framework

All inspection data is first captured from the field using electronic systems and repositories, including PowerDB acceptance and maintenance test data management software for substation assets as well as GIS Mobile Inspector for distribution assets. Data from these systems is then manually extracted into a series of Microsoft Excel files referred to as "data loaders", which contain all input data, including asset and inspection data, active calculations and results associated with the ACA framework. Health index results are then manually applied as part of other applications. For instance, results are leveraged to perform risk assessments for substation assets. This is further discussed in Chapter 4. However, at present time, health index results are not automatically integrated into Hydro Ottawa's Copperleaf C55 asset investment planning (AIP) software for the purposes of performing investment prioritization.

In general, this manual extraction/transfer of data from enterprise systems (i.e. PowerDB, GIS Mobile Inspector) into stand-alone Excel files (i.e. the data loaders) remains unintuitive, and can result in data loss or errors. Furthermore, as per the current-state process, health index results associated with historical maintenance procedures are not currently stored. Storage of historical health index data is necessary in order to sufficiently link the health index results to the time domain, to ascertain the typical amount of time for a given asset class or sub-class to move from a Very Good condition category to a Very Poor condition category. Establishing such a linkage is necessary in order to eventually derive a condition-based failure probability function based upon the local operating conditions of the utility and its asset base.

Therefore, as part of future-state improvements, it is recommended that Hydro Ottawa attempt to integrate the entirety of the ACA framework and calculation of the health index within an enterprise system, such that (a) in-field collected data can be directly transferred into the ACA framework, (b) historical HI results can be sufficiently stored and tracked against historical maintenance procedures, and, (c) data loss and/or errors associated with manual data extraction and loading can be avoided.

Hydro Ottawa currently utilizes the Copperleaf C55 asset investment planning (AIP) software in order to perform risk evaluation of its asset base, and health index results from the ACA framework are integrated into the C55 software and leveraged as part of the risk evaluation. Actual prioritization of investments, however, continue to be performed outside of the C55 environment within Microsoft Excel spreadsheets.

Hydro Ottawa did establish an implementation roadmap in 2017 in order to identify the current-state gaps within the C55 environment and introduce recommended solutions for investment prioritization. The desired end-state is to have all outputs from the ACA framework available in a common, auditable, accessible and convertible format [2].

The future-state roadmap defines a strategy whereby all inspection and testing data is available within a "central electronic repository", and that this data is then uploaded into the C55 environment for further analysis and evaluation. Figure 2.6 illustrates this future-state roadmap.

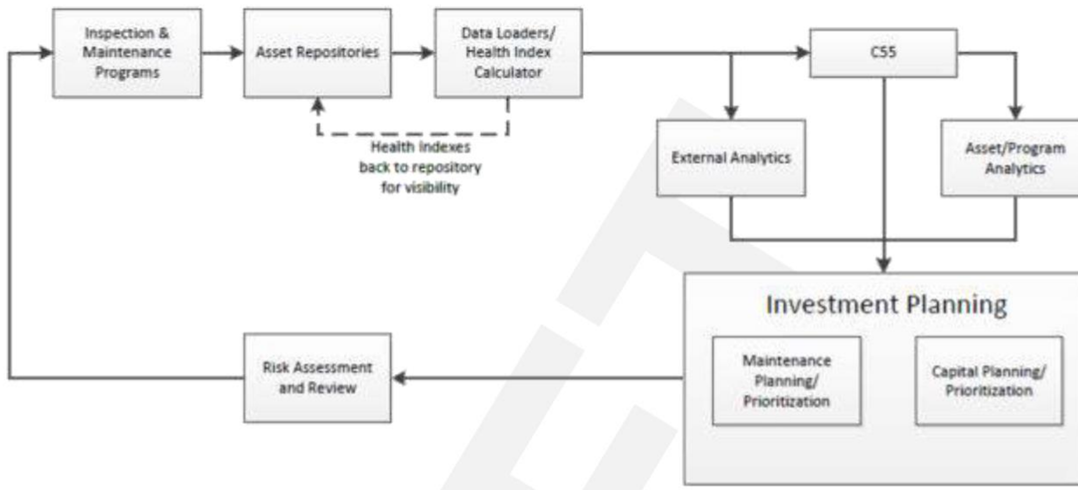

Figure 2.6 – Desired End-State Process Flow [2]

One of the shortcomings of this desired end-state is that the current data loaders that contain the calculation of the health index results will remain separate elements, and data will have to continue to be uploaded separately into the C55 environment. The process flow in Figure 2.6 also does not appear to provide any provisions for the storage of historical HI results as they relate to historical inspection and testing results.

As per continuous improvements, it is recommended that Hydro Ottawa further transition the HI calculations from the current data loader Excel files into an enterprise system environment, which is ideally also managing the key AM decision-making procedures, including investment prioritization. Ideally, data should be seamlessly acquired from the in-field mobile inspection software platforms, transformed accordingly into a health index leveraging contained calculation modules, and the HI results should then be immediately accessible by the AM decision-making and investment planning modules.

3 Review of Individual Asset Class Health Index Formulations & Results

Hydro Ottawa's ACA framework ingests input data, including inspection, testing and monitoring data, in order to produce health index results for the following evaluated asset classes:

- Substation assets:
  - Power transformers
  - Transformer tap changers
  - High-Voltage (>44kV) Switchgear (SF_6 breakers, Circuit Switchers)
  - Medium-Voltage (<44kV) Switchgear (Vacuum, Oil, SF_6, Air-insulated breakers, Oil reclosers)

- Overhead distribution assets:
  - Wood poles
  - Gang-operated load-break switches (Manual, SCADA)
  - Pole-mounted overhead transformers
  - Line reclosers

- Underground distribution assets:
  - Underground cables (PILC, XLPE/TRXLPE/EPR)
  - Underground distribution transformers (Pad-mounted, vault)
  - Underground switches (Pad-mounted, vault)
  - Manholes

Each of the associated health index formulations and results for the asset classes above were explored and assessed as part of this initiative. This chapter provides the results from the analysis along with future-state recommendations and continuous improvement opportunities.

As noted in Section 2.4, the associated ACA framework for the asset classes noted above are contained within stand-alone Microsoft Excel files referred to as "data loaders". The files are self-contained, in that they contain all of the necessary information and calculations, including input data copied over from the mobile inspection software, health index formulations, degradation factors and associated underlying calculations for each degradation factor. As part of this assessment, each of these files was individually reviewed and validated. The following subsections provide the results from this assessment.

Each health index formulation was reviewed and compared against an "ideal state" formulation based upon best practices as identified by METSCO. Input data was examined, and sample sizes (i.e. availability of input data to support a given degradation factor) was assessed.

3.1 Station Power Transformers

Figure 3.1 illustrates the current-state health index formulation for Station Power Transformers, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters. Testing parameters such as dissolved gas analysis (DGA), insulator power factor, infrared scanning and oil quality along with monitoring parameters such as load history remain highly weighted when compared to the visual inspection results which can be more subjective in nature. However, it should be noted that the majority (99%) of insulator power factor test results currently remain unavailable across the station power transformers asset class.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Dissolved Gas Analysis (DGA)	10	10	A - E	
Load History	10	10	A - E	
Insulation Power Factor	10	10	A - E	99% of asset data unavailable (2 available)
Infrared Scanning	10	10	A - E	
Oil Quality	8	8	A, C, E	
Degree of Polymerization (DP)	6	6	A - E	1.2 % of asset data unavailable (165 available)
Bushing	5	5	A - E	
Main Tank	2	2	A - E	
Cooling	2	2	A - E	
Oil Tank	1	1	A - E	
Foundation	1	1	A - E	
Grounding	1	1	A - E	
Gasket & Seals	1	1	A - E	
Connectors	1	1	A - E	
Oil Leaks	1	1	A - E	
Oil Level	1	1	A - E	
Overall Condition	6	6	A - E	

Figure 3.1 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Power TX

Figure 3.2 illustrates the total number of power transformer data records that are being ingested within the ACA framework and converted into an HI result. Currently, all power transformers (100%) receive a valid HI result.

Source	Asset Count	Sample Size
Asset Registry	167	
Health Index Sheet	167	
Assets w/ valid HI	167	100%

Figure 3.2 – Asset Counts from Data Input Sources

When examining the health index formulation within the Power Transformer data loader file, a calculation error was identified where the normalized health index result is being generated. As originally indicated in Equation 1, the sum of the weighted degradation factor scores for the evaluated asset is to be divided with the maximum possible score that the evaluated asset can receive based upon the HI formulation. In this case, the Foundation parameter within the denominator incorrectly uses the assets' actual weighted result, rather than the maximum possible score. Because this error is limited to only the Foundation degradation factor – which represents just 1 of the 17 total degradation factors considered within the formulation, and because the Foundation factor carries the low weighting of 1, the impact that this error has on the entire calculation is very minor. When this error is corrected via an adjusted formulation, only a single asset shifts from the Very Good condition category down to the Good condition category. Therefore, the overall effect of this error on the results is extremely minimal.

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. This adjustment ultimately results in more power transformers receiving a "Good" condition score rating, as opposed to the "Very Good" condition score rating.

In addition, there is an opportunity to apply a gateway approach within the Power Transformer health index formulation. "Ideal" state HI formulations based upon industry best practices will consider gateway rules applied to both the Dissolved Gas Analysis (DGA) and Oil Quality degradation factors. Where either of these degradation factors are assigned the worst score of "E" or 0, the entire health index will be divided by two, to account for the significant degradation occurring within the transformer.

Figure 3.3 illustrates the difference between the current-state Hydro Ottawa formulation and results, and the adjusted formulation that uses the adjusted formulation with corrections from the data loader, applies the industry standard condition ranges for the Good category and also applies gateway rules to the DGA and Oil Quality degradation factors. These results illustrate both a shift of power transformers into the Very Good category, as well as further distribution of assets between the Poor and Good categories respectively.

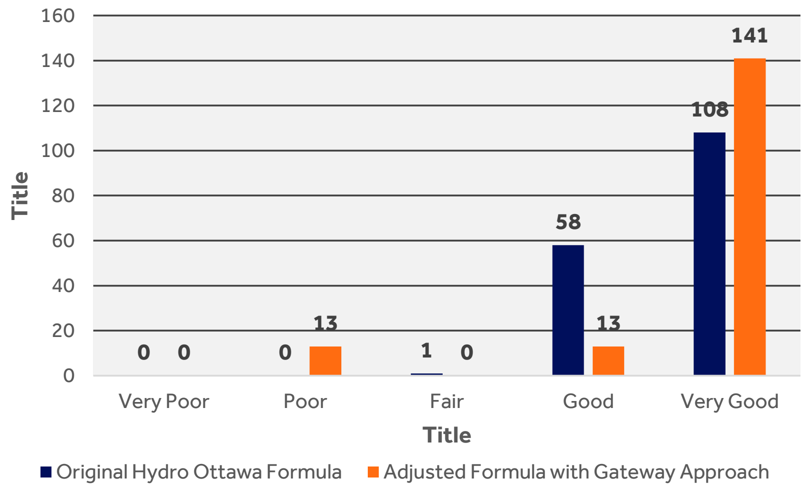

Figure 3.3 – Comparison between Current Hydro Ottawa Results & Adjusted Formula (with industry standard condition ranges, formula corrections and gateway rules) Results

Figure 3.4 illustrates a comparison between the service age of the power transformers and the corresponding health index results. This comparison serves to better understand the effectiveness of the degradation factor results and underlying data and how that compares to the aging of the assets. Following the adjustments to the HI formula using the gateway approach and applying the industry standard condition ranges, we see a distribution of assets in Poor condition, along with assets in Good and Very Good condition. It is notable that the one asset over the age of 60 appears to be in Very Good condition. However, when examining the underlying testing and inspection data results, there are no anomalies identified, and this particular transformer appears to be functioning properly even given its advanced age.

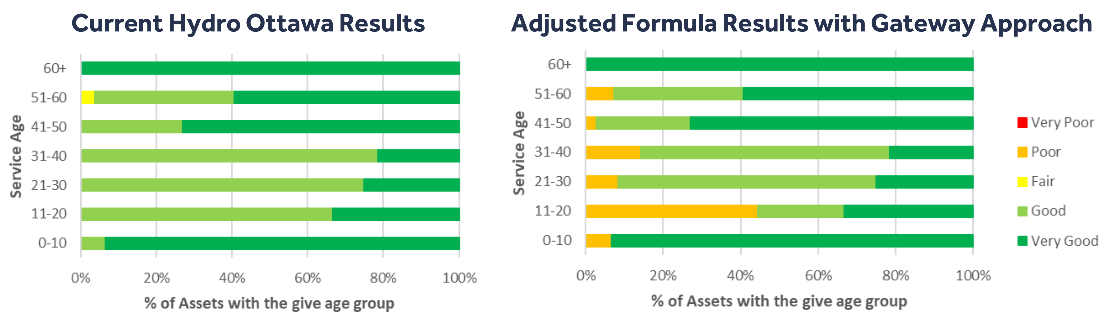

Figure 3.4 – Service Age versus Health Index Results

Approximately 33% of power transformers possess an on-load tap changer (OLTC), and these power transformers will receive a separate HI scoring for the OLTC assets as per the formula shown in Figure 3.5. This figure illustrates that Hydro Ottawa's current formulation is exactly aligned to the industry-standard "Ideal" formulation with respect to degradation factors and weights. However, it should be noted that 18.2% of OLTC assets do not possess appropriate DGA results. However, in general, all OLTC assets do receive an HI score.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Tank Condition	3	3	A – E	
Gaskets, Seals & Pressure Relief	2	2	A, C, E	
LTC Control & Mechanism Cabinet	3	3	A – E	
Dissolved Gas Analysis (DGA)	4	4	A – E	18.2% of asset data unavailable
Oil Quality Tests	3	3	A, C, E	18.2% of asset data unavailable

Figure 3.5 – Comparison between Hydro Ottawa & Ideal-State HI Weights

It should be noted that a grade of "B" (numerical score of 3) was identified for 25% of power transformers under the "Gaskets, Seals and Pressure Relief" degradation factor, and for 2% of power transformers under the "Oil Quality Tests" degradation factor. However, based upon the health index formulation guidelines for OLTC assets as illustrated in Figure 3.7 [1], a three-point grading system using only "A", "C" and "E" parameters is used for these two degradation factors. It is not known why these particular assets received a "B" grade for these two factors respectively.

Continuous improvement opportunities for the power transformer asset class include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges. Gateway methodologies should be considered for the DGA and Oil Quality degradation factors. Finally, the overall health index calculation and assigned grades should be revisited to ensure that final results are as accurate as possible, and that they align to the documented formulas.

3.2 High-Voltage SF_6 Circuit Breakers

Figure 3.6 illustrates the current-state health index formulation for Station High-Voltage SF_6-Insulated Circuit Breaker assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate that Hydro Ottawa leverages the majority of factors and weightings from the ideal-state formulation.

It should be noted that Hydro Ottawa's ACA guidelines [1] document the usage of a Grading Capacitor degradation factor, which is also contained within the ideal-state formulation. However, this factor currently remains unused within the HI formulation.

Approximately 36% of the high-voltage SF_6 circuit breakers do not have any scoring data available for the SF_6 leaks, Tank and Mechanism Box, Bushing/Support Insulators, Control & Operating Mechanism Components, Foundation, Support Steel, Grounding and Overall Condition degradation factors respectively. For the remaining factors, there is no data (100%) available at all. This means that across the entire asset class, there is not one single asset that receives a score with 70% or more data, meaning that there are ultimately no assets within this particular class that receive a valid health index score.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Air/Hydraulic/Spring Recharge Time	2	2	A, E	100% of asset data unavailable
SF6 Gas Analysis	3	3	A – E	100% of asset data unavailable
Coil Signature Test	4	4	A – E	100% of asset data unavailable
Timing/Travel Tests	3	3	A – E	100% of asset data unavailable
Contact Resistance Tests	2	2	A – E	100% of asset data unavailable
Infrared Scan (IR)	4	4	A, C, E	
SF_6 Leaks	4	4	A – E	36.4% of asset data unavailable
Tank and Mechanism Box	4	4	A – E	36.4% of asset data unavailable
Bushing/Support Insulators	4	4	A – E	36.4% of asset data unavailable
Control & Operating Mechanism Components	2	2	A – E	36.4% of asset data unavailable
Foundation, Support Steel, Grounding	3	3	A – E	36.4% of asset data unavailable
Overall Condition	4	4	A – E	36.4% of asset data unavailable
Grading Capacitor	2	2	A – E	Not used in formula (although it is defined within Hydro Ottawa's ACA guidelines)

Figure 3.6 – Comparison between Hydro Ottawa & Ideal-State HI Weights for High-Voltage SF_6 Circuit Breakers (Highlighted fields represent areas of future improvements)

Figure 3.7 illustrates the total number of SF_6 circuit breaker data records that are being ingested within the ACA framework and converted into an HI result. Currently, none of Hydro Ottawa's SF6 breakers (0%) receive a valid HI result, due to the fact that all of these assets fall below the 70% data availability threshold.

Source	Count	Sample Size
Asset Registry	20	
Health Index Sheet	22	
Assets w/ valid HI	0	0%

Figure 3.7 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. This adjustment ultimately results in more SF_6 breakers receiving a "Good" condition score rating, as opposed to the "Very Good" condition score rating.

As no valid health indices can be produced at this time, no further analysis was undertaken for this asset class. There is an opportunity to apply a gateway approach within the SF_6 Breaker health index formulation. "Ideal" state HI formulations based upon industry best practices will consider gateway rules applied to the Bushing/Support Insulator condition, SF_6 leaks (gas pressure and/or SF_6 refill rate), and the contact resistance test results. If the bushing / support insulator degradation factor score is the lowest ("E" or 0), the entire health index is divided by 2. If either SF_6 leaks and/or contact resistance test results score an "E", the entire health index score is multiplied by 0.75.

As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across this population of circuit breakers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges. Gateway methodologies should be considered for the Bushing/Support Insulator condition, SF_6 leaks and the contact resistance test degradation factors. Finally, it is recommended that the Grading Capacitor degradation factor be considered as part of a future update to the formulation.

3.3 High-Voltage Circuit Switchers

Figure 3.8 illustrates the current-state health index formulation for Station High-Voltage Circuit Switcher assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

Approximately 55% of the high-voltage circuit switchers do not have any scoring data available for the Insulators/Porcelains, Drive Train Assembly, Motor Operator & Controls, Disconnect Live Parts, Connectors/Conductors/Foundation, Support Steel and Grounding degradation factors. None of the circuit switcher assets possess underlying data for the Timing/Travel Test and Contact Resistance Test degradation factors respectively.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Timing/Travel Tests	3	3	A - E	100% of asset data unavailable
Contact Resistance Tests	3	3	A – E	100% of asset data unavailable
Infrared Scan (IR)	6	6	A, C, E	
Insulators/Porcelains	3	3	A – E	54.5% of asset data unavailable
Drive Train Assembly	4	4	A - E	54.5% of asset data unavailable
Motor Operator and Controls	3	3	A - E	54.5% of asset data unavailable
Disconnect Live Parts	3	3	A - E	54.5% of asset data unavailable
Connectors and Conductors	3	3	A - E	54.5% of asset data unavailable
Foundation, Support Steel, Grounding	3	3	A - E	54.5% of asset data unavailable

Figure 3.8 – Comparison between Hydro Ottawa & Ideal-State HI Weights for High-Voltage Circuit Switchers

Due to the data availability, only 5 out of the total 11 circuit switchers (i.e. 45% sample size) receive a valid health index score that exceeds 70% in available data. This is further illustrated in Figure 3.9.

Source	Count	Sample Size
Asset Registry	7	
Health Index Sheet	11	
Assets w/ valid HI	5	**45%**

Figure 3.9 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. However, in this case, there is no effect when adjusting to the industry standard 70-85 condition range.

Figure 3.10 illustrates a comparison between the service age of the circuit switchers and the corresponding health index results. This comparison serves to better understand the effectiveness of the degradation factor results and underlying data and how that compares to the aging of the assets. In this case, all circuit switchers are found to be in the Very Good category – however this may also be a function of the limited sample size due to the limited data availability.

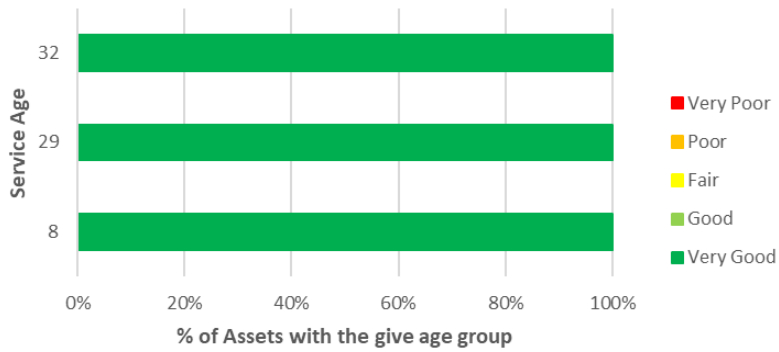

Figure 3.10 – Service Age versus Health Index Results

As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across this population of circuit switchers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

3.4 Station Reclosers

Figure 3.11 illustrates the current-state health index formulation for Station Recloser assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

Approximately 28% of the station reclosers do not possess input data to support the Tank/ Enclosure, Oil Leaks and Operating Mechanism & Controls degradation factors respectively. Approximately 19% of the station reclosers do not possess input data to support the Infrared Scan degradation factor. Approximately 9% of the station reclosers do not possess age data. There is no input data available (100%) to support remaining degradation factors including Condition of Terminations, Condition of Oil and Counter Readings respectively.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Infrared Scan (IR)	4	4	A - E	19.3% of asset data unavailable
Age	3	3	A - E	8.77% of asset data unavailable
Tank/Enclosure	3	3	A - E	28% of asset data unavailable
Condition of Terminations	2	3	A - E	100% of asset data unavailable
Condition of Oil	2	2	A - E	100% of asset data unavailable
Counter Readings	3	3	A - E	100% of asset data unavailable
Operating Mechanism & Controls	2	2	A - E	28% of asset data unavailable
Oil Leaks	2	2	A - E	28% of asset data unavailable

Figure 3.11 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Station Reclosers

Figure 3.12 illustrates the total number of station recloser data records that are being ingested within the ACA framework and converted into an HI result. Currently, none of Hydro Ottawa's station reclosers (0%) receive a valid HI result, due to the fact that all of these assets fall below the 70% data availability threshold.

Source	Count	Sample Size
Asset Registry	52	
Health Index Sheet	57	
Assets w/ valid HI	0	0%

Figure 3.12 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. However, in this case, there is no effect when adjusting to the industry standard 70-85 condition range.

As no valid health indices can be produced at this time, no further analysis was undertaken for this asset class. As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across the population of station reclosers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

3.5 Vacuum Circuit Breakers within Metalclad Switchgear

Figure 3.13 illustrates the current-state health index formulation for Vacuum Circuit Breaker assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

Approximately 73% of the vacuum circuit breakers do not possess input data to support the Contact Resistance test degradation factor respectively. Approximately 84% of the vacuum circuit breakers do not possess input data to support the Timing/Travel test degradation factor.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Timing/Travel tests	3	3	A – E	83.6% of asset data unavailable
Contact resistance tests	4	4	A – E	72.7% of asset data unavailable
Metalclad Cubicle and components	3	3	A – E	
Breaker truck condition	3	3	A – E	
Operating mechanism and controls	2	2	A – E	
Vacuum bottle integrity	5	5	A – E	
General condition of circuit breaker	4	4	A – E	

Figure 3.13 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Vacuum Circuit Breakers

Figure 3.14 illustrates the total number of vacuum circuit breaker data records that are being ingested within the ACA framework and converted into an HI result. Currently, health index results are only available for 24% of the vacuum circuit breaker population, due to the fact that the remaining assets fall below the 70% data availability threshold.

Source	Count	Sample Size
Asset Registry	230	
Health Index Sheet	55	
Assets w/ valid HI	55	24%

Figure 3.14 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. However, in this case, there is no effect when adjusting to the industry standard 70-85 condition range.

Figure 3.15 illustrates a comparison between the service age of the vacuum circuit breakers and the corresponding health index results. This comparison serves to better understand the effectiveness of the degradation factor results and underlying data and how that compares to the aging of the assets. In this case, nearly all vacuum circuit breakers are found to be in the Very Good category. It should be noted that at least 7 vacuum breakers were omitted from this analysis as no installation ages could be identified. The results below may also be a function of the limited sample size due to the limited data availability.

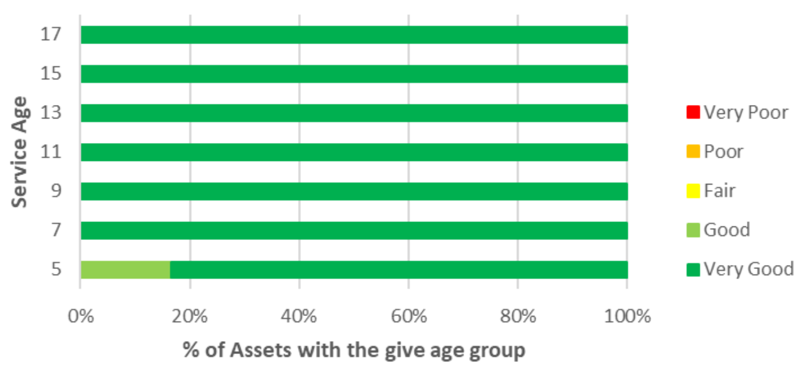

Figure 3.15 – Service Age versus Health Index Results

Only a single asset is identified as being in Good condition. Despite the fact that the vacuum circuit breaker in question is only 5 years old, it received the worst possible grade (E/0) for Contact Resistance, resulting in a Good rating.

As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across this population of vacuum circuit breakers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

3.6 Oil Circuit Breakers within Metalclad Switchgear

Figure 3.16 illustrates the current-state health index formulation for Oil Circuit Breaker assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

Approximately 91% of the oil circuit breakers do not possess input data to support the Oil Analysis test degradation factor respectively. Approximately 18% of the oil circuit breakers do not possess input data to support the Timing/Travel testing and Contact Resistance testing degradation factors respectively.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Timing/travel tests	3	3	A - E	18.4% of asset data unavailable
Contact resistance	4	4	A - E	18.4% of asset data unavailable
Oil Analysis	2	2	A - E	90.8% of asset data unavailable (7 available)
Cubicle and components	3	3	A - E	
Breaker truck	3	3	A - E	
Operating mechanism and controls	2	2	A - E	
Oil leaks	2	2	A - E	
General condition of circuit breaker	4	4	A - E	

Figure 3.16 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Oil Circuit Breakers

Figure 3.17 illustrates the total number of oil circuit breaker data records that are being ingested within the ACA framework and converted into an HI result. Currently, health index results are available for 79% of the oil circuit breaker population.

Source	Count	Sample Size
Asset Registry	78	
Health Index Sheet	76	
Assets w/ valid HI	62	**79%**

Figure 3.17 – Asset Counts from Data Input Sources

When examining the health index formulation within the Oil Circuit Breaker data loader file, a calculation error was identified where the normalized health index result is being generated. As originally indicated in Equation 1, the sum of the weighted degradation factor scores for the evaluated asset is to be divided with the maximum possible score that the evaluated asset can receive based upon the HI formulation. The sum in the numerator must include all available degradation factors. However, in this case, the Oil Analysis degradation factor has been omitted from the numerator calculation. This factor is, however, included in the denominator when calculating the maximum score. Seven assets in total were found to contain Oil Analysis testing results, and these assets shifted on average from approximately 77% up to 85% due to the error. As the assets would remain in "Good" condition, this error results in minimal impacts overall.

The data loader file also contained issues with regards to calculating the total number of assets within the various condition categories. As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. Figure 3.18 illustrates the difference between the current-state Hydro Ottawa formulation and results, and the adjusted formulation that both corrects the issues identified within the data loader file and also utilizes the industry standard condition ranges for the Good category. This figure illustrates that even with these changes implemented, the impact to the results is extremely minimal, with only two assets shifting from the Very Good to the Good category.

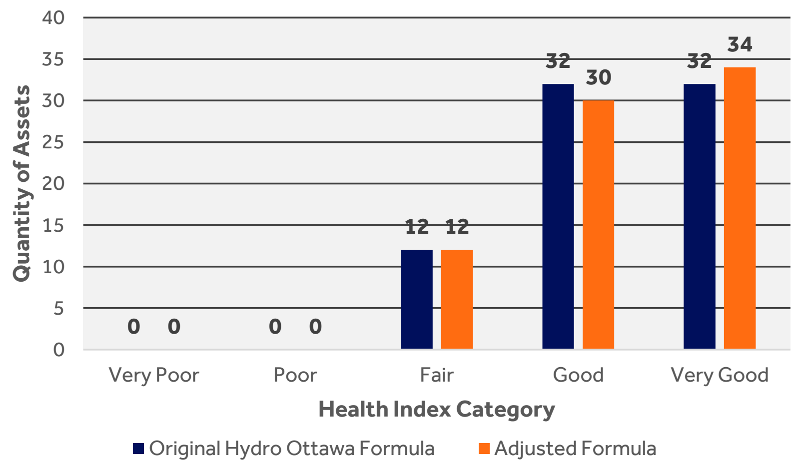

Figure 3.18 – Comparison between Current Hydro Ottawa Results & Adjusted Formula (with industry standard condition ranges and formula corrections) Results

Figure 3.19 illustrates a comparison between the service age of the oil circuit breakers and the corresponding health index results. This comparison serves to better understand the effectiveness of the degradation factor results and underlying data and how that compares to the aging of the assets. In this case, as the population ages, we see a growth of assets in the "Good" condition category and a proportional decrease of assets in the "Very Good" category. It should be noted that 22 oil circuit breakers were omitted from this analysis due to the fact that they are missing installation age data.

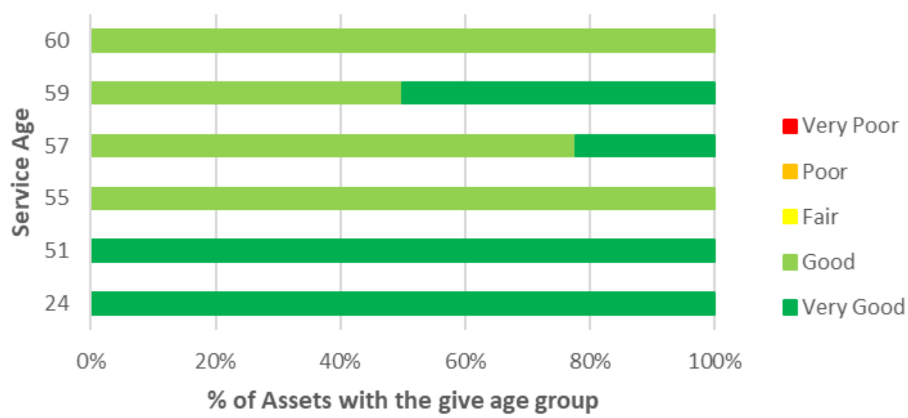

Figure 3.19 – Service Age versus Health Index Results

As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that age data can be captured across the board and overall sample size can be further maximized. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

3.7 SF_6 Circuit Breakers within Metalclad Switchgear

Figure 3.20 illustrates the current-state health index formulation for SF_6-Insulated Circuit Breaker assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

There is no (100%) input data available to support the Timing/Travel testing, Contact Resistance testing, SF_6 gas testing and SF_6 coil signature testing degradation factors respectively.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Timing/Travel tests	3	3	A - E	100% of asset data unavailable
Contact resistance test	4	4	A - E	100% of asset data unavailable
SF_6 Gas Test	3	3	A - E	100% of asset data unavailable
SF_6 Coil Signature Tests	3	3	A - E	100% of asset data unavailable
Cubicle and components	3	3	A - E	
Breaker truck	3	3	A - E	
Operating mechanism and controls	2	2	A - E	
SF_6 leaks	2	2	A - E	
General condition of circuit breaker	4	4	A - E	

Figure 3.20 – Comparison between Hydro Ottawa & Ideal-State HI Weights for SF_6 Circuit Breakers

Figure 3.21 illustrates the total number of SF_6 circuit breaker data records that are being ingested within the ACA framework and converted into an HI result. Currently, none of

Hydro Ottawa's SF_6 circuit breakers (0%) receive a valid HI result, due to the fact that all of these assets fall below the 70% data availability threshold.

Source	Count	Sample Size
Asset Registry	116	
Health Index Sheet	72	
Assets w/ valid HI	0	0%

Figure 3.21 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. However, in this case, there is no effect when adjusting to the industry standard 70-85 condition range.

As no valid health indices can be produced at this time, no further analysis was undertaken for this asset class. As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across the population of station reclosers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

3.8 Air-Blast Circuit Breakers within Metalclad Switchgear

Figure 3.21 illustrates the current-state health index formulation for Air-Blast Circuit Breaker assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results indicate an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

Approximately 58% of the air-blast circuit breakers do not possess input data to support the Travel/Timing test degradation factor respectively. Approximately 56% of the air-blast circuit breakers do not possess input data to support the Contact Resistance test degradation factor.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Timing/travel tests	3	3	A - E	57.5% of asset data unavailable
Contact resistance	4	4	A - E	56.2% of asset data unavailable
Cubicle and components	3	3	A - E	
Breaker truck	3	3	A - E	
Operating mechanism and controls	2	2	A - E	
Air chute	3	3	A - E	
General condition of circuit breaker	4	4	A - E	

Figure 3.22 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Air-Blast Circuit Breakers

Figure 3.23 illustrates the total number of air-blast circuit breaker data records that are being ingested within the ACA framework and converted into an HI result. Currently, health index results are only available for 28% of the air-blast circuit breaker population, due to the fact that the remaining assets fall below the 70% data availability threshold.

Source	Count	Sample Size
Asset Registry	614	
Health Index Sheet	393	
Assets w/ valid HI	174	28%

Figure 3.23 – Asset Counts from Data Input Sources

As first explained in Section 2.2, Hydro Ottawa's current-state ACA framework contains a deviation in health index ranges exclusive to substation assets, whereby the "Good" category has been adjusted from the industry standard range of 70-85 up to an expanded range from 70-90. In general, such an adjustment would result in more assets receiving a "Good" condition score due to the expanded range. Figure 3.24 illustrates the difference between the current-state Hydro Ottawa formulation and results, and the adjusted formulation that utilizes the industry standard condition ranges for the Good category. This figure illustrates that even with these changes implemented, the impact to the results is extremely minimal, with only one asset shifting from the Good to the Very Good category.

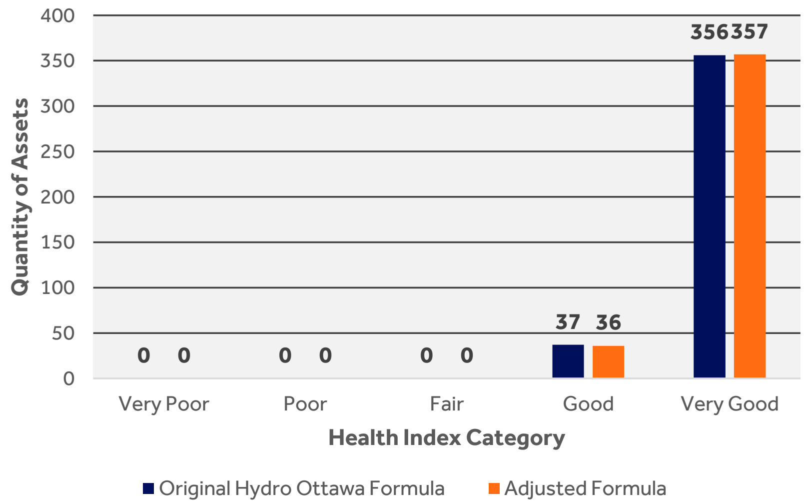

Figure 3.24 – Comparison between Current Hydro Ottawa Results & Adjusted Formula (with industry standard condition ranges) Results

Figure 3.25 illustrates a comparison between the service age of the air-blast circuit breakers and the corresponding health index results. This comparison serves to better understand the effectiveness of the degradation factor results and underlying data and how that compares to the aging of the assets. In this case, the vast majority of the air-blast circuit breakers are found to be in the Very Good category, despite the increasing ages. When examining the oldest population of breakers (63 years of age), these were found to have perfect (A/4) testing and inspection results. Conversely, a batch of brand new circuit breakers installed in 2018 were found to have grades of "B" (3) across all testing and inspection results.

As part of future improvement opportunities, it is recommended that Hydro Ottawa capture additional cycles of data for this asset class such that valid health indices can be produced across this population of air-blast circuit breakers. Other opportunities include potentially revisiting the adjusted health index category ranges, to either document the rationale around the expanded Good category range, or to revert to the industry standard ranges.

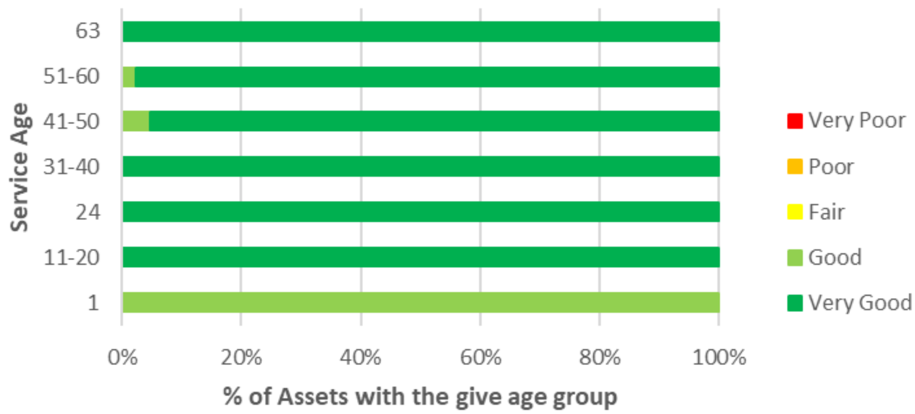

Figure 3.25 – Service Age versus Health Index Results

3.9 Distribution Manholes

Figure 3.26 illustrates the current-state health index formulation for Distribution Manhole assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results possess a close alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the distribution manhole analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. Approximately 32% of the distribution manholes are marked as "unknown" with respect to the Wall Condition degradation factor, for instance. Approximately 30% of manholes are marked as "unknown" with respect to the Access Location or Cover Size degradation factors respectively. Approximately 19% of the manholes are marked as "unknown" with respect to Roof, Collar and Floor condition respectively. Despite these missing datasets, due to the manner in which "unknown" data is handled, every manhole receives a health index value, as illustrated in Figure 3.27.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Roof Condition	6	6	A - E	19% are "Unknown"
Collar Condition	4	4	A - E	19% are "Unknown"
Wall Condition	2	2	A - E	32% are "Unknown"
Floor Condition	2	2	A - E	19% are "Unknown"
Access Location	7	14	A,C,E	30% are "Unknown"
Cover Size	7		A,C,E	30% are "Unknown"
Flooding and Mitigation		7		Not used in formula

Figure 3.26 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Distribution Manholes (Highlighted fields represent areas of future improvements)

Source	Count	Sample Size
Asset Registry	3758	
Health Index Sheet	3758	
Assets w/ valid HI	3758	100%

Figure 3.27 – Asset Counts from Data Input Sources

Health index ranges for all distribution assets align with the industry standards. As part of continuous improvements, it is recommended that Hydro Ottawa focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets). Finally, it is recommended that Hydro Ottawa consider additional degradation factors, such as Flooding & Mitigation, to better align with the "ideal" formulation.

3.10 Distribution Overhead Switches

Figure 3.28 illustrates the current-state health index formulation for Distribution Overhead Switch assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results possess an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the distribution overhead switch analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. Almost all (99%) of the evaluated overhead switch assets contain "unknown" data, resulting in Very Good scoring for nearly all (99%) assets within the population.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Age	4	4	A - E	99% are "Unknown"
Insulator	2	2	A - E	99% are "Unknown"
Blades	2	2	A - E	99% are "Unknown"
Operating Mechanism	2	2	A - E	99% are "Unknown"
IR Scan	4	4	A - E	99% are "Unknown"

Figure 3.28 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Distribution Overhead Switches

Figure 3.29 illustrates the total number of distribution overhead switch data records that are being ingested within the ACA framework and converted into an HI result. Currently, health index results are available for 97% of the distribution overhead switch population. This is mostly driven by the aforementioned rules on assigning "unknown" records the highest grades.

Source	Count	Sample Size
Asset Registry	5939	
Health Index Sheet	5792	
Assets in Registry but no HI	153	
Assets with HI but not found in Registry	6	
Assets w/ valid HI	5739	95%

Figure 3.29 – Asset Counts from Data Input Sources

It should be noted that all of the overhead switches within the data loader file were found to receive an "unknown" age result, despite actual age data being available for at least 15% of the population. Formatting issues within the "Age" field were identified as being a reason why an "unknown" age result was produced across this asset class. By reformatting this "Age" field, and by leveraging this "Age" field in combination with the "Install Date" field, a greater a number of overhead switches can receive actual age values.

When corrected, there was negligible impact to the results (99% of the switches remain in Very Good condition) – this is largely due to the fact that these assets are fairly new from a demographics perspective. However, by executing this adjustment, the sample size also increases to 100%. It should be noted that this still assumes that for remaining "unknown" records, a perfect grade of "A"/4 will be received.

Health index ranges for all distribution assets align with the industry standards. As part of continuous improvements, it is recommended that Hydro Ottawa focus on those inspection records with missing age data and attempt to populate these records with actual findings. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets).

3.11 Distribution Underground Switches

Figures 3.30 illustrates the current-state health index formulation for air-insulated pad-mounted switches as well as vault switches, and Figure 3.31 illustrates the formulation for SF_6-insulated underground pad-mounted switches respectively. These results possess an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the distribution overhead switch analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Age	4	4	A - E	
IR Scan	8	8	A - E	
Enclosure	3	3	A - E	
Pad	4	4	A,C,E	
Terminations		2	A - E	Not used in formula
Blades	2	2	A - E	
Operating Mechanism	2	2	A - E	

Figure 3.30 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Air-Insulated Pad-Mounted Underground Switches

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Age	4	4	A - E	
IR Scan	8	8	A - E	
Enclosure	3	3	A - E	
Pad	4	4	A,C,E	
Terminations		2	A - E	Not used in formula
SF_6 Leaks	8	8	A, E	

Figure 3.31 – Comparison between Hydro Ottawa & Ideal-State HI Weights for SF6-Insulated Pad-Mounted Underground Switches

Figure 3.32 illustrates the total number of distribution overhead switch data records that are being ingested within the ACA framework and converted into an HI result. Currently, health index results are available for 100% of the distribution underground switch population. This is mostly driven by the aforementioned rules on assigning "unknown" records the highest grades.

Source	Count	Sample Size
Asset Registry	995	
Health Index Sheet	995	
Assets w/ valid HI	995	100%

Figure 3.32 – Asset Counts from Data Input Sources

Health index ranges for all distribution assets align with the industry standards. As part of continuous improvements, it is recommended that Hydro Ottawa focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets). Furthermore, it is recommended that Hydro Ottawa utilizes a combination of both known age and install data fields to provide a more complete data set for the Age degradation factor, similarly to how it is done for the remaining assets identified. Finally, it is recommended that Hydro Ottawa consider additional degradation factors, such as Terminations, to better align with the "ideal" formulation.

3.12 Wood Poles

Figure 3.33 illustrates the current-state health index formulation for Wood Pole assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results possess an close alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the wood pole analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. Approximately 57% of wood poles are marked as "unknown" with respect to the Crossarm, Pole Top, Shell Thickness, Woodpecker damage and Insect infestation respectively.

Despite these missing datasets, due to the manner in which "unknown" data is handled, every wood pole receives a health index value, as illustrated in Figure 3.34.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Age	15	15	A - E	
Crossarm	1	1	A,C,E	57% are "Unknown"
Pole Top	1	1	A,C,E	57% are "Unknown"
Shell	1	1	A,C,E	57% are "Unknown"
Wood Pecker Damage	1	1	A,C,E	57% are "Unknown"
Insect Infestation	1	1	A,C	57% are "Unknown"
Remaining Strength	20	20	A - E	
Pole Treatment		5	A - E	
Out of Plumb		2	A - E	

Figure 3.33 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Wood Poles (Highlighted fields represent areas of future improvements)

Source	Count	Sample Size
Asset Registry	48,366	
Health Index Sheet	48,366	
Assets w/ valid HI	48,366	100%

Figure 3.34 – Asset Counts from Data Input Sources

This is the only HI formula within Hydro Ottawa's ACA framework that does apply a gateway model specific to remaining strength. Where remaining strength is less than 30%, the entire health index will be set to 0 (Very Poor). Where remaining strength falls between 31% - 60%, the overall health index will be divided by 2. There is no effect on the health index where remaining strength exceeds 60%.

Furthermore, a crossarm will be scheduled for replacement if the crossarm condition receives a score of "E" but the overall wood pole still possesses a HI of 50 or greater, meaning that the pole will not be replaced in the near term but the crossarm will require near-term intervention.

One opportunity for improvement would be to establish specific strength bands to each of the degradation categories for the Pole Strength factor, as opposed to the current approach where the Remaining Strength is multiplied by a factor of 0.04. Hydro Ottawa should continue to focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets).

Additional degradation factors that Hydro Ottawa should consider moving forward include the Pole Treatment degradation factor, as well as the Out of Plumb degradation factor, which are both considered as part of best industry practices.

3.13 Distribution Underground Transformers

Figure 3.35 illustrates the current-state health index formulation for Underground Transformer assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results possess an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the underground transformer analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. All transformers are marked as "unknown" with respect to Peak Loading, while approximately 9% of transformers are marked as "unknown" with respect to visual inspection and civil structure, and approximately 10% of transformers are marked as "unknown" with respect to infrared scanning results respectively. Despite these missing datasets, due to the manner in which "unknown" data is handled, every underground transformer receives a health index value, as illustrated in Figure 3.36.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Transformer Age	3	3	A - E	
Peak loading	3	3	A - E	100% is "Unknown"
Visual Inspection	4	4	A,C,E	9% are "Unknown"
IR Scans	4	4	A - E	10% are "Unknown"
Civil Structure	4	4	A,C,E	9% are "Unknown"

Figure 3.33 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Distribution Underground Transformers

Source	Count	Sample Size
Asset Registry	17,314	
Health Index Sheet	17,314	
Assets w/ valid HI	17,314	100%

Figure 3.34 – Asset Counts from Data Input Sources

Moving forward, Hydro Ottawa should continue to focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. In particular, an automated process should be established to capture peak loading data, as this data tends to change more dynamically, thus providing more dynamic condition-based outputs. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets).

3.14 Distribution Overhead Transformers

Figure 3.35 illustrates the current-state health index formulation for Overhead Transformer assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. These results possess an exact alignment to the ideal-state formulation in terms of weightings and grade letters.

To account for missing data, the overhead transformer analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. All transformers are marked as "unknown" with respect to Peak Loading and Infrared Scanning results, while approximately 60% of transformers are marked as "unknown" with respect to visual inspection results respectively. Despite these missing datasets, due to the manner in which "unknown" data is handled, every overhead transformer receives a health index value, as illustrated in Figure 3.36.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Transformer Age	3	3	A - E	
Peak loading	3	3	A - E	100% is "Unknown"
Visual Inspection	4	4	A - E	60% are "Unknown"
IR Scans	4	4	A - E	100% are "Unknown"

Figure 3.35 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Distribution Overhead Transformers

Source	Count	Sample Size
Asset Registry	15,670	
Health Index Sheet	15,670	
Assets w/ valid HI	15,670	100%

Figure 3.36 – Asset Counts from Data Input Sources

Moving forward, Hydro Ottawa should continue to focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. In particular, an automated process should be established to capture peak loading data, as this data tends to change more dynamically, thus providing more dynamic condition-based outputs. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets).

3.15 Underground Polymeric (XLPE/TRXLPE) Cables

Figure 3.37 illustrates the current-state health index formulation for Underground Polymeric Cable assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. Several parameters from the ideal-state formula are currently considered within Hydro Ottawa's HI formulation.

This formulation focuses on the evaluation of cross-linked polyethylene (XLPE) and tree-retardant cross-linked polyethylene (TR-XLPE) cables. Generally, these cables, especially when direct-buried, can be very difficult to inspect and maintain. At the same time, these are some of the most expensive assets to manage when they fail. Therefore, it is necessary to have a strong health index to provide enhanced insight on what cables should ultimately be replaced in a proactive manner.

This formulation appears to apply a similar practice as other distribution assets to assume a best grade ("A"/4) in cases where data is currently missing, in order to maximize the sample size, as illustrated in Figure 3.38. Currently, all cables receive a perfect grade with respect to the Condition of the Concentric Neutral as well as Visual Inspection results. However, as noted for other distribution assets, this practice of apply a perfect rating to degradation parameters with "unknown" results can mask those cables that may be legitimately deteriorating.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Cable Age	5	5	A - E	
Condition of Concentric Neutral	4	4	A, C	All cables receive a score of "A"
Visual Inspection	1	1	A	All cables receive a score of "A"
Field Tests		5		
Failure Rates		5		
Loading History		2		

Figure 3.37 – Comparison between Hydro Ottawa & Ideal-State HI Weights for U/G Cables (Highlighted fields represent areas of future improvements)

Source	Count	Sample Size
Asset Registry	75,256	
Health Index Sheet	75,256	
Assets w/ valid HI	75,256	100%

Figure 3.38 – Asset Counts from Data Input Sources

As only cable age appears to be derived from actual results, this particular formulation ends up being entirely age-based, and may provide little insight with respect to actual condition of the cable. As part of future improvements, it is recommended that Hydro Ottawa consider additional condition-based variables that can be readily be captured for this type of asset class when taking into consideration the very limited options available for maintenance and inspection practices.

This includes the inclusion of field testing data. In particular, Hydro Ottawa has performed extensive work with CableQ utilizing their non-destructive DC polarization/depolarization current measurement technique which can measure the depolarization current within polymeric cables to proactively detect water treeing. The $\%Q_{Dep}$ parameter produced from this procedure can ultimately be converted into a numerical grade, which can then be incorporated into the health index.

In addition, Hydro Ottawa also possesses historical failure data (captured in the form of number of faults per 10km of cable) regarding their underground cable population. This data should be incorporated into the HI calculation as part of future enhancements. Finally, the loading history on cables can determine the overall utilization and stress levels that the cable has experienced. As loading history is largely dynamic, its inclusion into the formulation can result in dynamic condition-based results. These variables should be considered into the formulation, and a greater weighting should be applied towards these variables as they are generally easier to capture within Hydro Ottawa's current AM framework and procedures. Hydro Ottawa should generally discontinue the practice of arbitrarily assigning perfect grades to parameters in order to maximize sample size, as this can mask real issues that are present within the system.

3.16 Underground Paper-Insulated Lead Covered (PILC) Cables

Figure 3.39 illustrates the current-state health index formulation for Underground Paper-Insulated Lead Covered (PILC) cable assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. Several parameters from the ideal-state formula are currently considered within Hydro Ottawa's HI formulation.

Compared to polymeric cables that are buried within conduit or earth (direct-buried), PILC cables are generally easier to maintain and inspect within manholes. However, the current formula does not consider visual inspection of either the cable or splice. Currently, the formulation only considers cable age as well as the quantity of failures for every 10km of cable. The formulation does not apply any assumed values due to "unknown" records, and a HI result is successfully captured for every PILC cable segment, as illustrated in Figure 3.40.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Cable Age	4	4	A - E	
# of Failures per 10km	5	5	A - E	
Infrared Scans		6		
Failed Cable Tests		6		
Loading History		5		
Visual Inspection of Splices		3		

Figure 3.39 – Comparison between Hydro Ottawa & Ideal-State HI Weights for U/G PILC Cables (Highlighted fields represent areas of future improvements)

Source	Count	Sample Size
Asset Registry	9,504	
Health Index Sheet	9.504	
Assets w/ valid HI	9,504	100%

Figure 3.40 – Asset Counts from Data Input Sources

As part of future improvements, it is recommended that additional inspection, testing and monitoring telemetry is considered as part of the formulation. This includes infrared scanning and visual inspection of splices, which can be performed within manholes as per standard maintenance practices. This also includes cable testing and loading history parameters, which can provide significantly greater detail and insight into the performance of the evaluated cables in question.

3.17 Distribution Overhead Reclosers

Figure 3.41 illustrates the current-state health index formulation for Distribution Overhead Recloser assets, and provides a comparison of degradation factor weightings and grade letters between Hydro Ottawa's current-state formulation and an "ideal-state" formulation based upon best practices. There are mostly close alignments between the ideal-state formulation and Hydro Ottawa's implementation, although some weights have been adjusted.

Degradation Factors	Hydro Ottawa Weights	Ideal-State Weights	Grade Letters	Comments
Service Age	3	3	A - E	
Cond. of Tank/Enclosures	3	3	A - E	100% are "Unknown"
Cond. of Terminations	2	2	A - E	100% are "Unknown"
Counter Reading	3	3	A - E	100% are "Unknown"
Cond. of Operating Mechanism	2	2	A - E	100% are "Unknown"
IR Scans	4	4	A - E	100% are "Unknown"
Air Leak	4	2	A - E	100% are "Unknown"
Oil Leak	2	2	A - E	100% are "Unknown"
Vac. Bottle Integrity	4	6	A - E	100% are "Unknown"
SF6 Leak	4	6	A - E	100% are "Unknown"

Figure 3.41 – Comparison between Hydro Ottawa & Ideal-State HI Weights for Distribution Overhead Reclosers

To account for missing data, the distribution overhead recloser analysis identifies degradation factors with "unknown" datasets, and will assume the best grade of "A"/4 to account for these instances. All (100%) of the evaluated overhead reclosers contain "unknown" data for all degradation factors apart from asset age. This means that this is largely an age-driven formulation.

This represents a conservative approach whereby if the condition of the asset is not known, then the score should not be discounted, and rather, the best score should be assigned. While this approach does maximize the amount of assets receiving a health index result, it also assigns a perfect grade for a particular degradation factor, irrespective of whether the asset in question may actually be in worse shape, thereby masking possible deficiencies within the system. At the same time, by applying this approach, all reclosers receive an HI result, as illustrated in Figure 3.42.

Source	Count	Sample Size
Asset Registry	52	
Health Index Sheet	52	
Assets w/ valid HI	52	100%

Figure 3.42 – Asset Counts from Data Input Sources

As part of continuous improvements, it is recommended that Hydro Ottawa focus on those inspection records with "unknown" telemetry and attempt to populate these records with actual findings. It is also recommended that the approach of assigning the best possible scoring to unknown records is revisited, and perhaps where information is missing, the degradation factors should simply be dropped from the formulation, or the asset will not receive a score at all if its data availability falls below 70%, thus aligning to calculation approaches of other asset classes (e.g. Stations assets).

4 Current-State Applications of the ACA Framework

Figure 4.1 illustrates the broader Asset Management & Expenditure process, which includes the ACA Framework and its interactions with input data (i.e. asset register and testing/inspection/maintenance programs) as well as the outputs that it supplies (i.e. risk assessment and the broader capital expenditure process).

As first explained in Section 2.4, while ACA data is directly loaded into the Copperleaf C55 asset investment planning (AIP) software – which is designed to manage key elements within the capital expenditure process, including risk assessment, project prioritization and optimization – the actual health index formulations and calculations continue to be managed within a series of Microsoft Excel files referred to as "data loaders". Note that project prioritization is also currently undertaken outside of the C55 environment, and results are manually transferred into other capital expenditure procedures in order to undertake the prioritization efforts.

Figure 4.1 – Asset Management & Expenditure Process

In addition, data inputs from maintenance, testing and inspection programs are not directly or automatically transferred into the data loader files. These efforts currently occur manually. Due to the nature of these manual processes of getting data in and out of the data loaders, and due to the nature of the data loader files being in a Microsoft Excel spreadsheet environment, there are currently no processes to historically store ACA data for the purposes of tracking the amount of time taken to transition from a Very Good condition down to a Very Poor condition. Such processes would be necessary should Hydro Ottawa wish to establish their own condition-based failure probability curves into the future.

Hydro Ottawa does currently leverage an industry-derived function that converts the health index into an effective probability of failure value. This function is applied as part of a broader risk modelling approach for substation assets in order to perform a reliability risk assessment on a station level for major substation assets. This analysis considers not only the probability of failure but also the impacts of failure based upon customer impacts and derives a risk cost to quantify the total effects of asset failure.

It is recommended that Hydro Ottawa continue to expand the applications of the ACA framework, by further expanding upon either a reliability risk approach, or by considering an economically-driven risk-based AM approach, in which the costs of risk are balanced against the capital costs of offsetting these risks in order to determine an economic end-of-life result for the evaluated assets in question. This analysis can be further leveraged to create business cases for each investment performed within the system.

As explained in Section 2.4, Hydro Ottawa did establish an implementation roadmap in 2017 in order to establish a desired end-state such that ACA results are available in a common, auditable, accessible and convertible format [2]. One of the key features of this future state is having input data accessible from a central electronic repository, and being able to upload results from the ACA framework into the C55 environment for further analysis and evaluation. This process was further illustrated in Figure 2.6. One of the shortcomings of this approach was that the health index formulations would remain contained within a series of Excel-based spreadsheets.

As noted throughout the detailed investigation in Chapter 3, there have been instances where calculation errors have been identified with respect to the HI results. The overall impact of these errors has been determined in every case to be relatively minor in nature, and often with little or no impacts to the final health index category results. However, as more data is captured and as more HI results are produced, there is a risk of these calculations resulting in greater error and impacts over time. These errors are largely due to the open nature of the Excel environment, and how data is manually loaded and extracted from this environment to support the various AM applications. It is recommended that Hydro Ottawa consider a more integrated automation strategy whereby input data collected from the field is directly integrated into the ACA framework, and results from the framework (i.e. the HI results) are directly produced, extracted and sent into the appropriate AM processes to support capital investment decision-making.

5 Overall Conclusions of Assessment

As noted in Chapter 1, METSCO undertook this assignment of assessing Hydro Ottawa's current-state ACA framework as per the following three stages:

(a) Review of the overarching processes, systems and associated input data that are supporting the ACA framework, which is subsequently discussed in Chapter 2.

(b) Review of the asset-class HI formulations, including the produced results and sample sizes, which is subsequently discussed in Chapter 3.

(c) Review of the end-state applications produced by the ACA framework, including how the HI results are ultimately integrated into broader AM deliverables, which is subsequently discussed in Chapter 4.

From these individual assessments, a number of conclusions and recommendations can be established in order to further improve upon Hydro Ottawa's ACA framework moving into the future.

The review of the overarching processes, systems and associated input data provided indication that Hydro Ottawa's ACA framework is well integrated within the broader AM process – albeit with manual processes required to ingest input data and transfer outputs – the health index results – into other AM-related processes, procedures and outcomes. Hydro Ottawa has developed detailed and robust documentation both for the ACA framework itself, including the underlying health index formulations, as well as for the underlying maintenance programs that supply inputs to the ACA framework.

It was uncovered during the investigation that the Overhead Line Inspection working procedure document was found to contain the greatest amount of detail, with images of wood poles and insulators associated to degradation factor grade levels. This level of detail is necessary in order to allow for captured input data to be consistent from inspector to inspector, and it is strongly recommended that Hydro Ottawa expand this level of detail across all of their major asset classes.

When reviewing the health index formulation, a deviation with respect to the condition category ranges was identified for substation assets, in which Very Good assets are defined as being within the 90-100 range, and Good assets are defined as being within the 70-90 range, which effectively expands the range of the "Good" category while reducing the range of the "Very Good" category. This deviation was not found within the supporting documentation on the ACA framework as provided by Hydro Ottawa subject-matter experts, and is only applied to substation assets and not to distribution assets, which utilize the industry-standard Good range of 70-85 and Very Good range of 85-100. Further analysis on specific asset classes have indicated that this deviation has a very minimal impact on overall results. However, in general, it is recommended that Hydro Ottawa consider a common range of health index categories across all asset classes. If it is necessary to maintain a specialized set of condition ranges at the substation level, specific reasons and rationale for this deviation should be documented accordingly.

Detailed investigations on the health index formulations on an asset class basis revealed two areas for improvement. One concerned the use of Microsoft Excel as a platform to store the associated input data and perform the necessary calculations to produce the desired health index results. A number of calculation errors were identified during the course of the investigation that were largely due to the open nature of the Excel platform. Often, the errors in question were due to incorrect variables being utilized in a calculation, or incorrect data ranges being selected for use within a calculation. Integration of the ACA framework within a more automated, controlled and stable environment would ultimately reduce the possibility of calculation-related errors and ensure that the HI results are produced in the most consistent manner possible. With more automation, there is also the opportunity to expand further applications from the ACA framework, including the storage of historical health index results for the purposes of both validating the formulas and developing utility-specific condition-based failure probability functions.

On an overall whole, Hydro Ottawa's ACA framework can be described as utilizing robust formulations that are aligned or exactly proportional with an "ideal" state, in which degradation factors are in alignment with best practices. At the same time, however, one of the challenges in utilizing "ideal" state formulas is with respect to sample size, and being able to maximize the amount of health index results across evaluated assets within a given asset class.

Six out of the eight substation asset classes evaluated were found to be below a sample size of 50%, for instance. In these cases, where data is missing for a given degradation factor, the factor is simply removed from the formulation but a health index calculation can still be undertaken where overall available data exceeds 70%. With respect to distribution assets, a slightly different approach was undertaken, whereby missing records were marked as "unknown", and automatically assigned the highest grade values, regardless of the actual performance of those assets in question. While this approach can result in the masking of serious degradation issues for certain assets, it can also allow for readily expanded sample sizes to be achieved. As a result of this approach, all distribution assets are at or near 100% sample size, with nearly every asset being provided a health index result. At the same time, for some asset classes such as overhead transformers, underground polymeric cables and distribution reclosers, a significant proportion of the underlying input data has been marked as "unknown", with the only readily available input data being the age of the asset. Under these circumstances, the health index result is by-and-large age driven, and lacks the necessary condition-related telemetry to further indicate whether the assets are experiencing accelerated forms of degradation.

In general, it is recommended that Hydro Ottawa establish a common strategy between stations and distribution assets when it comes to missing data. Ultimately, we believe that the approach undertaken for substations is the more optimal approach, as data gaps remain highlighted and those assets with missing data can be easily targeted for enhanced data collection activities. The approach applied to distribution assets appears to mask data gap deficiencies by inflating the sample sizes of the asset classes, and can also mask real deficiencies and degradations that are occurring within the system.

Despite the errors and data gaps identified during the detailed investigation of the asset class formulations, it was identified that these errors and gaps do not materially affect the overall performance of the condition assessment results. Removing the error from within the HI calculation and recalculating the results was not found to materially shift results between health index categories, for instance. However, should the errors and data gaps remain within the ACA framework, there is a risk of the impacts becoming more broader and material, particularly as more input data is ingested into the ACA framework and as more HI results are produced across a greater number of assets within the system.

A final component of METSCO's evaluation involved establishing the overall maturity level of Hydro Ottawa's ACA framework. Figure 5.1 illustrates the four major maturity levels associated with ACA and HI implementation across distribution system assets.

In limited cases, such as with underground cables and wood poles, there are opportunities to introduce additional variables that can provide even further insight into the degradation of a given asset. However, on an overall whole, Hydro Ottawa's HI formulations are exactly or closely aligned with the best practices with respect to the degradation of assets, and have therefore achieved a Stage 4 level of maturity.

However, if we expand the evaluation to not only the formula, but also in terms of the nature of the calculation, the process in which the HI results are calculated, and data gaps that may impede the ability to capture accurate results, Hydro Ottawa's overall ACA framework would possess a maturity level of 3. From this perspective, a "full" recommended health index can be produced that considers the vast majority of ideal parameters. However, there remain many instances where parameters are either unavailable and marked as "unknown", or are dropped from the formulation, which can reduce the sample size of the calculation.

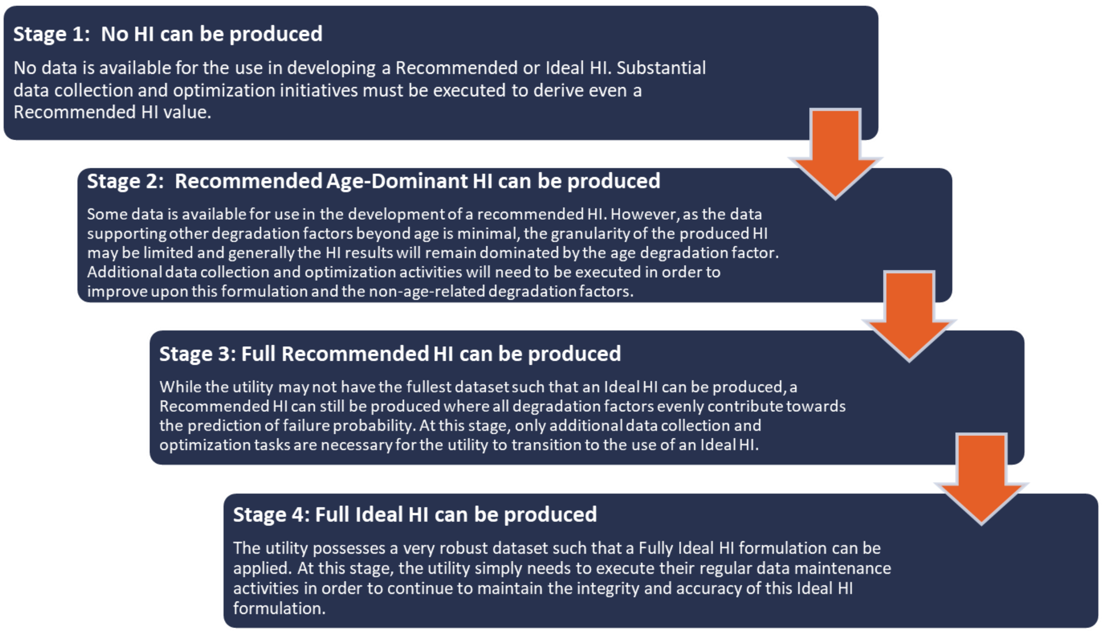

Figure 5.1 – Maturity Levels of ACA Framework

It is recommended that Hydro Ottawa continue to work on mitigating the existing data gaps, such that more degradation parameters can be assigned actual grades, thus expanding the sample size and/or capturing all possible degradations to the evaluated assets. Hydro Ottawa's testing, inspection and maintenance programs are already well positioned to continue to capture this information using automated processes and technologies such as in-field mobile devices. By further automating the ACA framework with respect to how data is ingested and how results are integrated into AM applications, Hydro Ottawa can establish a seamless architecture whereby data gaps are readily identified and mitigated, resulting in continuous improvement to HI results.

These results can then be further leveraged as part of various AM applications, including an expanded reliability risk analysis, an economically-driven risk-based AM approach, as well as investment and project prioritization and optimization. By executing upon these improvement strategies, Hydro Ottawa can further elevate the maturity levels of their ACA framework, and further ensure that the right actions are being undertaken to the right assets at the right time.

6 References

[1] "Asset Management & Expenditure Process", Hydro Ottawa Limited.

[2] "ACA / AIP Implementation Roadmap", 2017, Maintenance & Reliability Planning Group, Hydro Ottawa Limited.

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Below is a summary of findings by asset class based on spreadsheet files and documentation provided by Hydro Ottawa.

Distribution Assets

08_HO DataLoader - DX Cable, DCAB (Aug 2019)

- No issues

09_HO DataLoader - DX Cable, DPILC (Aug 2019)

- No issues

10_HO DataLoader - DX Manholes, DMAN (Aug 2019)

- No issues

14_HO DataLoader - DX Pole, DPOLE (Sep 2019) - demographics update

- No issues

15_HO DataLoader - DX Reclosers, DOHRCL (Aug 2019)

- No issues

16_HO DataLoader - DX SWGear UG & Vault (Aug 2019)

- No detailed documentation in **GEG0001 - Asset Health Index Guideline R0 - Updated Draft** for SF6 Leaks (i.e. missing table for breakdown)
- In the workbook, sheet **ACA Mapping** columns D:F are not aligned with columns H:I or what is in the word document
    - However, no impact on HI since columns D:F are not used, suggest for removal or for correction for consistency

17_HO DataLoader - DX XFRMs, Polemount, DPXFRM (Aug 2019)

- No detailed documentation in **GEG0001 - Asset Health Index Guideline R0 - Updated Draft** for Peak Loading (i.e. missing table for breakdown)
- Inconsistency with age bands between the Word file and the Excel workbook
- In the workbook, the validity calculation multiplies the value by 100 which makes all HI's invalid. Other workbooks do not contain the multiplication of 100. What is the purpose of it? Seems inconsistent and possibly incorrect?
- In the workbook, validity calculation takes into consideration the peak loading value however no asset has peak loading. A proxy Health Index can be used while this parameter is being collected

18_HO DataLoader - DX XFRMs, Underground, DUXFRM (Aug 2019)

- No detailed documentation in **GEG0001 - Asset Health Index Guideline R0 - Updated Draft** for Peak Loading (i.e. missing table for breakdown)
- Inconsistency with age bands between the Word file and the Excel workbook

- Minor discrepancy in count of assets reported in previous METSCO assessment and the current existing workbook (17314 (past) vs. 17045 (current))

21_HO DataLoader - DX Switch (Aug 2019)

- No issues

General observations for distribution asset workbooks

- Confirm if validity is >70% or >=70% as both versions are being used. The latter would be the preferred choice

GEG0001 - Asset Health Index Guideline R0 - Updated Draft

- Clarification should be included in the guideline for the HI bands; image below. In the workbook the ranges are applied appropriately for distribution assets with 85% HI belonging to 'Good'.
  - The table should be able to communicate this as well. 70% HI is considered to be 'Fair' for HOL and not 'Good', 50% HI is 'Poor' and not to be considered as 'Fair'. The syntax can be changed to something like "(70-85]", where square bracket is inclusive and round bracket is not.

Table 4-1 - Asset condition based on health index

Health Index	Condition	Description	Requirements
85–100	Very Good	Some ageing or minor deterioration of a limited number of components	Normal maintenance
70–85	Good	Significant deterioration of some components	Normal maintenance
50–70	Fair	Significant widespread deterioration or serious deterioration of specific components	Increase diagnostic testing; possible remedial work or replacement needed depending on criticality
30–50	Poor	Widespread serious deterioration	Start planning process to replace or rehabilitate considering risk and consequences of failure
0–30	Very Poor	Extensive serious deterioration	Asset has reached its end-of-life; immediately assess risk; replace or refurbish based on assessment

- Clarifications should be given to age bands for assets. An example where the clarification is appropriately document is found for XLPE/TRXLPE Cable:

Condition	Corresponding condition
A	Under 20 years of service
B	21 to 30 years of service
C	31 to 40 years of service
D	41 to 50 years of service
E	Over 50 years of service

- It is clear that age 21 for a cable is 'B'. In other age band tables this clarity is missing and can only be seen in the workbook in detail. For example wood pole documentation follows:

Table 6-2: Pole age condition score

Condition	Pole Age
A	0 to 10 years
B	10 to 30 years
C	30 to 40 years
D	40 to 50 years
E	Greater than 50 years

- It is unclear if age 10 belong to 'A' or belongs to 'B' though in the workbook the age band rules are applied the same to each unit. Having a clear guideline will ensure minimal disturbances between changes of ACA ownership at HOL

Station Assets

XFMR (Power Transformer)

- For the HI bands, the ranges are applied incorrectly for power transformers with 85% HI belonging to 'Very Good'. This is inconsistent with other assets where 85% HI belonging to 'Good'.
- Under "METSCO Calculation", columns "AS & AV", the weighting for each asset is not included in the numerator for Total Score calculation. However, this doesn't affect the HI demographics since these columns aren't used.

HVSF6Breaker

- "ACA Action Log" says 3 breakers where validated due to IR scan assumption, however, in the Health Index worksheet, all 33 breakers are invalid according to the 70% threshold (Error in ACA Action Log)
- Cell "AC3" Total Asset count is incorrect

HVCircuitSwitcher

- Cell "X3" Total Asset count is incorrect

Recloser

- "ACA Action Log" says 19 reclosers where validated due to IR scan assumption, however, in the Health Index worksheet, all 62 breakers are invalid according to the 70% threshold (Error in ACA Action Log)
- Cell "V3" Total Asset count is incorrect

MetBreakerAir

- Formulas used to calculate the count for ache HI band is incorrect, for example: Very poor: 0-30%, Poor: 30%-50%, this should be Very poor: 0-30%, Poor: >30%-50%.
- Formula for Column U are incorrect, all the rows referencing to wrong cells
- Comparing to the Asset Registry, The Asset Registry contains 614 Air CB, where as the Health Index worksheet contains 570 Air CB, 44 Breakers missing in the Health Index worksheet
- Cell "S3" Total Asset count is incorrect

MetBreakerSF6

- The formula in column "T" had an extra comma, fixing the formula doesn't affect the Health Index Demographics
- Cell "V3" Total Asset count is incorrect

MetBreakerOil

- The formula in column "T" had an extra comma, fixing the formula doesn't affect the Health Index Demographics
- Cell "U3" Total Asset count is incorrect
- Comparing to the Asset Registry, The Asset Registry contains 78 Oil CB, where as the Health Index worksheet contains 58 Oil CB, 20 Breakers missing in the Health Index worksheet

MetBreakerVac

- Formula for Column T are incorrect, all the rows referencing to wrong cells
- Cell "R3" Total Asset count is incorrect

INTERROGATORY RESPONSE - CCC-61

CCC-61

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M, p. 3

SUBJECT AREA: Distribution System Plan

Metsco indicates Hydro Ottawa is also leveraging an industry-derived function that allows for the conversion of the health index into an effective probability of failure value.

Please identify and provide details on this industry-derived function.

RESPONSE:

Hydro Ottawa is leveraging an industry-derived function that allows for the conversion of the health index into an effective probability of failure value. For this function, please see Attachment CCC-61(A): Health Index Conversion Function. This function was developed with Metsco as part of the ACA framework and is applied as part of a broader risk modelling approach for substation assets in order to perform a reliability risk assessment at the station level for major substation assets.

INTERROGATORY RESPONSE - CCC-62

CCC-62

EXHIBIT REFERENCE:

Ex. 2-4-3, Attachment M, p. 1

SUBJECT AREA: Distribution System Plan

Metsco undertook the work in three stages: a) review of the overarching processes, systems and associated input data that are supporting the ACA framework, (b) review of the asset-class HI formulations, including the produced results and sample sizes, and (c) review of the end-state applications produced by the ACA framework, including how the HI results are ultimately integrated into broader AM deliverables.

Did Metsco undertake a gap analysis as part of its review? If yes, please provide the results.

RESPONSE:

a) Yes, please refer to Attachment CCC-60(A): Hydro Ottawa ACA Review - Initial Assessment.

INTERROGATORY RESPONSE - CCC-63

CCC-63

EXHIBIT REFERENCE:

Ex. 2-4-6, p. 5

SUBJECT AREA: Reliability

Please update Table 5 to include 2019 data.

RESPONSE:

Please see the response to interrogatory CCC-38.

INTERROGATORY RESPONSE - CCC-64

CCC-64

EXHIBIT REFERENCE:

Ex. 2-4-6, p. 9-10

SUBJECT AREA: Reliability

Please update Tables 8 and 9 to include 2019 data.

RESPONSE:

Please see the response to interrogatory SEC-57.

INTERROGATORY RESPONSE - CCC-65

CCC-65

EXHIBIT REFERENCE:

Ex. 4-1-1, p. 3 and 7

SUBJECT AREA: OM&A

Please provide the Board Approved OM&A Expenses for the years 2016-2020 in the same format as Table 2

RESPONSE:

The OEB-approved OM&A expense for the year 2016 was $83,105,564. This 2016 approved amount was increased annually using the approved escalator factor for 2017 through 2020, as described in the OEB's Decision and Order.[1] The OM&A envelope amounts for 2017 and 2018 were increased using an escalator of 1.91%, and were calculated on a compounded basis while 2019 and 2020 were increased by 1.55%.

Seeing as there is no Table 2 included in UPDATED Exhibit 4-1-1: Operations, Maintenance and Administration Summary, Hydro Ottawa is interpreting this interrogatory as referring to Table 1. Table A below is therefore replicated with OEB-approved amounts for the years 2016-2020. Note that, since the OM&A amount was approved as an envelope, the split for Property Tax cannot be provided.

[1] Ontario Energy Board, Decision and Order, EB-2015-0004 (December 22, 2015).

Table A – 2016-2020 Total OEB-Approved Operating Expenses ($'000,000s)

	2016	2017	2018	2019	2020
OM&A approved envelope	$83.1	$84.7	$86.3	$87.6	$89.0
Depreciation	$40.4	$43.6	$46.4	$48.2	$49.4
PILS	$3.8	$3.6	$4.9	$7.2	$6.2
TOTAL OEB-APPROVED	**$127.3**	**$131.9**	**$137.6**	**$143.0**	**$144.6**

INTERROGATORY RESPONSE - CCC-66

CCC-66

EXHIBIT REFERENCE:

Ex. 4-1-4, P. 18

SUBJECT AREA: OM&A

Please re-cast Table 10 to include Board approved OM&A Program Costs for the years 2016-2020.

RESPONSE:

The OEB-approved OM&A for 2016-2020 was on an overall envelope basis for 2016, with each following year's envelope escalated by an approved escalator factor, as described in the OEB's Decision and Order.[1] Therefore Table 10 cannot be re-cast to include OEB-approved OM&A on a program-by-program basis.

[1] Ontario Energy Board, *Decision and Order*, EB-2015-0004 (December 22, 2015).

INTERROGATORY RESPONSE - CCC-67

CCC-67

EXHIBIT REFERENCE:

Ex. 4-1-4, p. 18

SUBJECT AREA: OM&A

Please provide a detailed budget for each of the following OM&A categories for the years 2016-2021. Please include all assumptions:

a) Collections, Accounts and Activities

b) Corporate Costs

c) Customer and Community Relations

d) Customer Billing

e) Distribution Operations

f) Regulatory Affairs

RESPONSE:

Please see Table A below for Hydro Ottawa's detailed internal budget for each of the OM&A categories requested for the years 2016-2021 and the associated assumptions.

Please note that the numbers in superscript text that are affixed to certain OM&A categories in the table correspond to explanatory notes. These explanatory notes are located on pages 3-4 below.

Table A – OM&A Expenses ($'000,000s)*

OM&A Category	2016	2017	2018	2019	2020	2021
Collections, Accounts and Activities						
Compensation[1]	$1.6	$1.5	$1.6	$1.5	$1.5	$1.6
Bad Debt (Electricity Billing only)[2]	$1.4	$1.4	$1.4	$1.4	$1.5	$1.5
Collection Agency Fees, Credit Check, and Other[3]	$0.4	$0.2	$0.2	$0.2	$0.3	$0.3
Subtotal	**$3.4**	**$3.1**	**$3.2**	**$3.2**	**$3.3**	**$3.4**
Corporate Costs						
Compensation[1]	$(1.2)	$0.2	$(1.1)	$1.2	$1.2	$1.3
Corporate Cost Allocation[4]	$3.9	$4.2	$4.6	$3.8	$3.7	$3.8
Insurance[5]	$1.3	$1.5	$1.5	$1.6	$1.8	$1.9
Audit Fees, Legal, Courier, and Other[3]	$0.2	$0.4	$0.5	$0.4	$0.3	$0.4
Inflationary assumption[6]	$0.0	$0.0	$0.0	$0.0	$0.0	$0.3
Subtotal	**$4.3**	**$6.4**	**$5.5**	**$7.0**	**$7.1**	**$7.6**
Customer and Community Relations						
Compensation[1]	$4.4	$4.0	$4.3	$4.1	$4.4	$4.6
External Contact Centre[3]	$1.9	$1.7	$1.6	$1.6	$1.7	$1.7
IT Maintenance and Subscriptions[7]	$0.3	$0.3	$0.2	$0.2	$0.7	$1.1
Media Communication[3]	$0.6	$0.5	$0.7	$0.9	$0.9	$0.9
SLA Cost Reclassification[8]	$0.0	$0.0	$0.0	$0.0	$(0.6)	$(0.7)
OEB LEAP, Consulting, and Other[3]	$1.1	$1.1	$0.9	$1.1	$0.8	$0.8
Subtotal	**$8.2**	**$7.6**	**$7.7**	**$7.8**	**$7.9**	**$8.5**
Customer Billing						
Compensation[1]	$2.8	$2.8	$2.8	$3.1	$3.1	$3.2
Postage, Bill Production, and Other[9]	$2.6	$2.6	$2.7	$2.2	$2.1	$1.9
CC&B, Web applications, & Meter Data[10]	$4.5	$4.6	$4.3	$3.4	$3.4	$4.1
Subtotal	**$9.9**	**$9.8**	**$9.8**	**$8.7**	**$8.6**	**$9.2**
Distribution Operations						
Distribution Support Programs [3,11]	$3.0	$3.2	$3.8	$4.2	$4.6	$4.9
Dist Testing, Inspection & Maintenance[3,11]	$1.9	$1.7	$1.7	$2.2	$2.2	$2.2
System Operating [3,11]	$5.7	$5.3	$5.1	$4.6	$5.1	$5.2
Vegetation Management[3,11]	$3.5	$3.5	$3.6	$4.2	$3.9	$3.9
Distribution Maintenance[3,11]	$1.9	$2.6	$2.6	$2.1	$2.4	$2.4
Stations[3,11]	$1.7	$1.6	$1.9	$2.1	$2.2	$2.2
Other[11]	$2.2	$2.4	$2.3	$0.8	$0.0	$0.6
Subtotal	**$19.9**	**$20.3**	**$21.1**	**$20.3**	**$20.4**	**$21.5**
Regulatory Affairs						
Compensation[1]	$1.0	$0.9	$0.9	$1.1	$1.3	$1.0
Regulatory Costs[12]	$1.5	$1.3	$1.3	$1.8	$1.3	$2.3
Other [3,8]	$0.1	$0.1	$0.0	$0.1	$(0.3)	$(0.3)
Subtotal	**$2.5**	**$2.2**	**$2.2**	**$3.0**	**$2.2**	**$3.0**

* Totals may not sum due to rounding

Assumptions:

1. Compensation accounts for a large portion of the total OM&A in these categories. It is budgeted at each position level with an overall assumption for vacancies. Each position is budgeted based on the negotiated collective agreement and required contributions for the Ontario Municipal Employees Retirement System ("OMERS"), as well as statutory and insured benefits. Historically, the vacancy allowance was budgeted in Corporate Costs (2016-2018). However, starting in 2019, the vacancy allowance was allocated to each individual business unit.
2. Bad Debt expense in the Collections, Accounts and Activities category represents bad debt expense related to electricity billings. It is budgeted based on the percentage of total electricity billing, including cost of power and distribution revenue. The percentage used for budgetary purposes remains flat. However, the overall bad debt expense increases proportionately with the increase in customer electricity bills.
3. The budget assumptions for these items are based on historical trending, estimated volumes, and negotiated contract pricing.
4. Corporate Cost Allocation is based on the estimated level of service provided by Hydro Ottawa Holding Inc. ("Holding Company").
5. Insurance premiums in the Corporate Costs category are budgeted based on anticipated increases in property coverage as a result of hardened insurance markets, along with an increase in property values (based on the third-party valuation).
6. For any non-compensation related costs budgeted in 2019 dollars for the year 2021, a general inflationary assumption was applied based on the Conference Board of Canada's Consumer Price Index - Canada. This inflationary increase for all OM&A categories was budgeted as a lump sum in corporate costs.
7. Assumptions for technology and automation are as outlined in Attachment 1-1-13(B): Digital Strategy and explained in section 2.7 of UPDATED Exhibit 4-1-4: Operations, Maintenance and Administration Cost Drivers and Program Variance Analysis.
8. Service Level Agreement ("SLA") Cost Reclassification - please see section 2.8 of UPDATED Exhibit 4-1-4: Operations, Maintenance and Administration Cost Drivers and

Program Variance Analysis. The cost recovery is budgeted based on the level of service provided to the affiliates.

9. Postage rates are based on historical increases, whereas the volume is based on customer growth offset by estimated e-billing penetration rates.
10. The Customer Care & Billing system ("CC&B"), Web applications, and Meter Data category are largely technology costs. In 2019 and 2020, the budget included Capital Labour Recovery from internal resources dedicated to the development, configuration, and implementation of the CC&B upgrade project. The project is scheduled to be completed in 2020, hence zero being budgeted in 2021 for Capital Labour Recovery.
11. "Other" in the Distribution Operations category comprises compensation for the maintenance and operation programs, offset with allocation recoveries, and other general and administrative costs such as small tools. Such costs are not allocated to the subprogram level. The allocation recoveries are budgeted based on the level of resources and the planned capital, maintenance, and work for others activities. The internal labour costs were budgeted at the program level, while the recoveries are in "Other."
12. Please see UPDATED Exhibit 4-2-4: Regulatory Costs and UPDATED Attachment 4-2-4(A): OEB Appendix 2-M - Regulatory Cost Schedule for the budget assumptions.

INTERROGATORY RESPONSE - CCC-68

CCC-68

EXHIBIT REFERENCE:

Ex. 4-1-5, p. 5

SUBJECT AREA: Compensation

Please explain, in detail why Hydro Ottawa's compensation costs area increasing by more than $10 million from 2016 to 2021. Of the $77.6 million of total compensation costs for 2021, how much is related to compensation that is the tied to collective agreements?

RESPONSE:

Hydro Ottawa's actual and forecast total compensation costs from 2016-2021 show an average increase of 2.5% per year. This includes an average 2% increase per year to total labour costs and an average 5% increase per year to benefits costs. Throughout this same period, Hydro Ottawa has replenished its trades workforce.

Of the $77.6M in total compensation costs for 2021, $51.1M is tied to collective agreements.

INTERROGATORY RESPONSE - CCC-69

CCC-69

EXHIBIT REFERENCE:

Ex. 4-2-1, p. 2

SUBJECT AREA: Shared Services & Corporate Cost Allocation

The evidence states that the shared services pricing model and methodology were developed internally and the services are provided under the terms of Service level Agreements. Has Hydro Ottawa ever had the models and methodology reviewed by independent external consultants? If not, why has it not? If so, please provide any reports regarding these reviews. In the absence of a third-party independent review how can ratepayers be assured the allocations and pricing are fair?

RESPONSE:

Hydro Ottawa has not had the shared corporate services pricing model and methodology reviewed by external consultants.

In 2016, the OEB undertook a review of Hydro Ottawa's shared corporate services cost allocation methodology. No deficiencies were identified and no report was received.

The intercompany allocations are one of the major areas that are reviewed and audited by the external auditors as part of the interim and year-end audits. No deficiencies with Hydro Ottawa's shared corporate services pricing methodology have been identified. The majority of allocations are activity-based. All allocations are routinely reviewed and adjusted to reflect changes in cost drivers.

INTERROGATORY RESPONSE - CCC-70

CCC-70

EXHIBIT REFERENCE:

Ex. 4-2-1

SUBJECT AREA: Shared Services & Corporate Cost Allocation

With respect to shared services, please explain in detail, the process used to record time spent and the number and/or value of transactions processed. Please provide an example of the time sheets. Please provide any directives provided to employees regarding shared services.

RESPONSE:

The labour hours associated with a specific transaction are tracked in a Work Order, or alternatively, costs are apportioned by the relative value of the services provided, where Work Orders are not utilized.

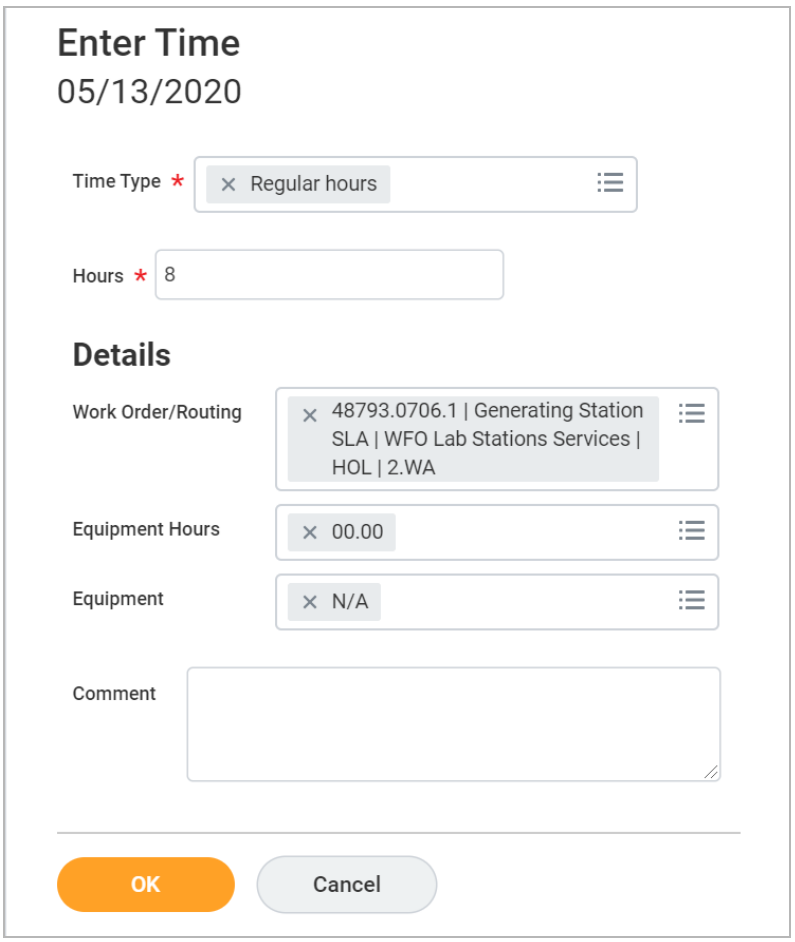
The Work Orders include electronic timesheets using Workday software. Please see Figure A below for a screenshot of an illustrative example of a time entry into the Workday system. Once the timesheets are approved, the labour hours are integrated within Hydro Ottawa's Enterprise Resource Planning ("ERP") system to produce the associated transaction costs for billing purposes. These transactional quantities and values are retained in the ERP and are relied upon for allocating costs to the affiliate Service Level Agreements ("SLAs") for estimates and during the year-end reconciliation process.

Many of the shared corporate services are priced according to the volume of transactions. For example, Accounts Payable service costs are allocated according to the number of payments processed. The volume is tracked in the ERP system. Services that are not volumetric or uniform in terms of costs are allocated on a basis that reflects the level of effort and/or value of the services performed. For example, Treasury Services are allocated on the basis of the value of debt outstanding.

SLA transactions, including estimated pricing, are reviewed and updated annually.

Directives are provided to employees regarding shared services. Employees are also routinely informed about the Affiliate Relationships Code compliance requirements and pricing rules, for affiliate transactions.

Figure A – Example of Workday Time Entry



INTERROGATORY RESPONSE - CCC-71

CCC-71

EXHIBIT REFERENCE:

Ex. 4-2-1, p. 6

SUBJECT AREA: Budget

The Holding Company is providing services to Hydro Ottawa in 2021 for an annual cost of $3.827 million. Please provide a detailed budget setting out all services provided to Hydro Ottawa and explain the nature of those services.

RESPONSE:

The detailed budget is shown in Attachment 4-2-1(A): OEB Appendix 2-N - Shared Services and Corporate Cost Allocation. Page 6 of Appendix 2-N provides the detailed Budget for 2021.

The nature of the services provided is as follows:

- Management services related to the President and Chief Executive Officer and Director of Corporate Planning and Governance. Services include guiding and approving the alignment of Hydro Ottawa business plans with strategic direction, approving budget plans and business strategy, advising and reporting to stakeholders on operational and financial results, ensuring all regulatory compliance and risk management frameworks are in place, ensuring that all required policies, programs, standards, and performance measures are in place, and supporting leadership and organizational development programs. The costs related to the Hydro Ottawa Limited Board of Directors are also included in this service.

- Finance, Internal Audit, and Enterprise Risk Management services include the provision of accounting services, financial services, the provision of advice and guidance on strategic and operational matters, and the preparation of reports for the Board of Directors and Audit Committees. They also include monitoring and evaluation of business planning practices and policies, liaising with other external stakeholders, and providing oversight on the development of departmental budgets, the five-year financial plan, annual financial statements, internal corporate policies and procedures, and strategic projects.

Internal audit services include the development and implementation of a three-year audit plan, evaluation of the effectiveness of risk management, corporate control and governance processes, provision of assessments to the audit committee, follow-up on management's action plans resulting from internal audits, and liaising with financial, regulatory, and other auditors.

Enterprise risk management ("ERM") includes the support and maintenance of the ERM for Hydro Ottawa, coordinating quarterly and annual risk assessments, providing oversight to business continuity planning, and conducting risk assessments as directed by the ERM steering committee or the Board of Directors.

- For Human Resources, please see the response to interrogatory VECC-88.

- Treasury services include maintenance of credit ratings, trustee reporting, cost of capital monitoring, arrangement of credit facilities, maintenance of external/internal financing transactions, ongoing monitoring of financial markets, and relations with financial institutions and credit rating agencies by senior management and executive staff.

- For Corporate Communications, please see the response to interrogatory VECC-88.

- Legal and Corporate Administration services include the provision of legal advice and opinions, litigation management and support, contract drafting and review, policy development, coordination of the representations to the Board of Directors, and point of contact and investigation coordinator of complaints made under the Business Conduct Hotline. Legal services also include the management of delivery of services by external legal counsel, research, and preparation and submission of responses to access to information requests and privacy complaints. Corporate administration services include the submission of corporate filings under the Ontario *Business Corporations Act* ("OBCA") and the *Corporations Information Act*, attendance at Board and Committee meetings for Hydro Ottawa Limited, preparation of associated agendas and minutes, and dissemination of Board decisions and reports. Corporate administration services also include the submission and maintenance of corporate register and corporate filings, and reporting of related party transactions involving directors and senior management.

- For Information Management and Technology, please see the response to interrogatory VECC-88.

INTERROGATORY RESPONSE - CCC-72

CCC-72

EXHIBIT REFERENCE:

Ex. 3-2-1, p. 1 and 9

SUBJECT AREA: Other Revenue

Please explain why the level of Specific Service Charges is decreasing in 2021 relative to historical levels. Please describe the methodology used to forecast Specific Service Charges. Is Hydro Ottawa seeking explicit OEB approval for its proposed Specific Service Charges, or simply approval of the forecasted revenue resulting from these charges?

RESPONSE:

The level of Specific Service Charges decreasing in 2021, relative to historical levels, is largely attributable to the following:

1) Account Set Up Charges: Hydro Ottawa is applying for a new rate of $25 in 2021, which represents a $5 reduction from the 2020 rate of $30. Please refer to section 2.1.2 of UPDATED Exhibit 3-2-1: Other Revenue Summary for additional details.
2) Specific Charge to Access Power Poles - Wireline: For the 2016-2020 period, Hydro Ottawa secured approval from the OEB for a utility-specific rate of $53 per pole per year. For the 2021 Test Year, Hydro Ottawa intends to move to the OEB's generic rate of $45.39, consistent with the policy established by the OEB in 2018. For details, please refer to section 2.1.9 of UPDATED Exhibit 3-2-1: Other Revenue Summary.

Hydro Ottawa uses historical trending to forecast Specific Service Charges unless there are proposed changes in Service Charges. Please see section 2.1 of UPDATED Exhibit 3-2-1: Other Revenue Summary for a description of the proposed changes and the associated drivers.

UPDATED Exhibit 8-7-1: Specific Service Charges also addresses the changes in Specific Service Charges rates and Attachment 8-7-1(A): Proposed and New Specific Service Charge Calculations provides the costing methodology for each Specific Service Charge.

And yes, Hydro Ottawa confirms that it is seeking approval for any proposed Specific Service Charge rate changes in this proceeding.

INTERROGATORY RESPONSE - CCC-73

CCC-73

EXHIBIT REFERENCE:

Ex. 3-2-1, p. 2

SUBJECT AREA: Other Revenue

Please provide a schedule setting out all current Specific Service Charges and the Specific Service Charges proposed for 2021. The evidence states that Hydro Ottawa undertook an internal costing review of many routine service charges to ensure that the associated costs of providing those services are appropriately recovered. Was a report prepared? If so, please provide a copy that report.

RESPONSE:

Please refer to UPDATED Exhibit 8-7-1: Specific Service Charges, which addresses the proposed changes in Specific Service Charges. Furthermore, Attachment 8-7-1(A): Proposed and New Specific Service Charge Calculations shows the costing methodology per Specific Service Charge. No report was prepared beyond the information provided within the aforementioned Exhibit.

INTERROGATORY RESPONSE - CCC-74

CCC-74

EXHIBIT REFERENCE:

Ex. 9-3-1, p. 4

SUBJECT AREA: Deferral and Variance Accounts

Does Hydro Ottawa intend to update its proposed rate riders for disposition of the deferral and variance account balances at any time? Please explain why the number of customers for each rate class differs in Table 3 and 4.

RESPONSE:

Hydro Ottawa updated the proposed rate riders for disposition as part of the update for 2019 actuals. Please refer to UPDATED Exhibit 9-3-1: Disposition of Deferral and Variance Accounts.

Hydro Ottawa intends to update the proposed rate riders for disposition throughout the Application process for any required changes.

Table 3 is the second year of a proposed two-year Group 2 rate rider. Hydro Ottawa proposes to use the 2022 forecast average customer count to dispose of the second year. Table 4 is the first year of a proposed rate rider for Account 1568 and is using the forecasted average numbers of customers for 2021.

Please note that Account 1568 (Table 4) was originally requested to be cleared over a one-year period. As part of the updates for 2019 actuals, Hydro Ottawa is requesting to clear Account 1568 over two years. Therefore, Table 4 now consists of both year one and year two rate riders.

INTERROGATORY RESPONSE - CCC - 75

CCC-75

EXHIBIT REFERENCE:

(Ex. 5-1-1, p. 8)

SUBJECT AREA: Cost of Capital

Question(s):

Please provide the approved and actual ROE for each year 2016-2019. Please provide the projected ROE for 2020.

RESPONSE:

Please refer to the response provided in interrogatory VECC-91 for the approved and actual annual Return on Equity ("ROE") for the 2016-2019 period.

Due to the uncertainty caused by the ongoing COVID-19 pandemic and the resultant impact on Hydro Ottawa's revenues and expenses, a reliable projection of ROE for 2020 is not available at this time.

INTERROGATORY RESPONSE - CCC-76

CCC-76

EXHIBIT REFERENCE:

Ex. 5-1-1, p. 2

SUBJECT AREA: Cost of Capital

Question(s):

Please explain why a short-term debt rate of 2.75% remains appropriate given the significant change in economic conditions that has occurred since the evidence was prepared.

RESPONSE:

Please refer to the response to interrogatory OEB-148 regarding the short-term debt rate of 2.75%.

INTERROGATORY RESPONSE - CCC-77

CCC-77

EXHIBIT REFERENCE:

Ex. 9-1-3, pp. 12-13

SUBJECT AREA: Deferral and Variance Accounts

Question(s):

Please explain how the forecast amounts in the Gains and Losses on Disposal of Fixed Assets Variance Accounts were determined. How much of this is related to storms?

RESPONSE:

Please refer to the response provided to part (b) of interrogatory OEB-179, which details how the forecast amounts in the Gains and Losses on Disposal of Fixed Assets Variance Accounts were determined.

The forecast amounts in the Gains and Losses on Disposal of Fixed Assets Variance Accounts do not reflect any forecast for significant storm damages, largely because in recent years Hydro Ottawa has not lost many newer assets. Many of the assets that have been lost in storms were fully depreciated.

INTERROGATORY RESPONSE - CCC-78

CCC-78

EXHIBIT REFERENCE:

Ex. 9-1-3, p. 14

SUBJECT AREA: Earning Sharing Mechanism

Question(s):

Please provide the ESM calculations for the years 2018 and 2019.

RESPONSE:

As a preface to this response, Hydro Ottawa has included a revised version of Table 8 from UPDATED Exhibit 9-1-3: Group 2 Accounts, which addresses data entry issues in the years 2016-2018 that were discovered in the process of preparing this response. For ease of comparison, Hydro Ottawa has first provided Table 8, as submitted in conjunction with the UPDATED 2019 actuals filing on May 5, 2020, and has then included a REVISED version of Table 8, that has been modified to address the data entry issues.

Thereafter, Table A below provides an updated version of Table 8 with 2019 data included.

Table 8 – AS UPDATED FOR 2019 ACTUALS – ESM Calculation ($’000s)[1]

	2016	2017	2018
Net Income (per RRR)	$33,483	$36,114	$34,605
Deduct Previous Years’ LRAM[2]	$(1,042)	$(1,081)	($1,081)
Add Current Year LRAM[3]	$773	$935	$935
PILS Grossed-up on CDM Adjustments[4]	$(172)	$222	($45)
Net Income after Adjustments	**$33,311**	**$36,336**	**$34,559**
Deemed Equity (per RRR)	$341,540	$357,578	$378,652
ESM Achieved ROE	9.75%	10.16%	9.13%
Deemed ROE	9.19%	9.19%	9.19%
% Return Above Deemed	**0.56%**	**0.97%**	**-0.06%**
Earnings Above Regulated Return	$1,924	$3,475	($239)
50% of Earnings above Regulated Return	$962	$1,737	$0
PILS Grossed-up[5]	$347	$626	$0
RATEPAYERS’ SHARE OF OVEREARNING[6]	**$1,309**	**$2,364**	**$0**

[1] “Current year” means 2016 for the purposes of the column with information for 2016, and 2017 for the purposes of the column with information for 2017.
[2] Previous years’ LRAM includes adjustment to any year not related to the current year.
[3] Current year LRAM includes adjustments in reporting years subsequent to the current year.
[4] Tax rate = 26.5%.
[5] Tax rate = 26.5%.
[6] Totals may not sum due to rounding.

Table 8 – AS UPDATED FOR 2019 ACTUALS AND AS REVISED – ESM Calculation ($'000s)[7]

	2016	2017	2018
Net Income (per RRR)	$33,483	$36,114	$34,605
Deduct Previous Years' LRAM[8]	$(1,042)	$(1,081)	($482)
Add Current Year LRAM[9]	$773	$1,429	$411
PILS Grossed-up on CDM Adjustments[10]	$(97)	$125	($26)
Net Income after Adjustments	**$33,311**	**$36,336**	**$34,559**
Deemed Equity (per RRR)	$341,540	$357,578	$378,652
ESM Achieved ROE	9.75%	10.16%	9.13%
Deemed ROE	9.19%	9.19%	9.19%
% Return Above Deemed	**0.56%**	**0.97%**	**-0.06%**
Earnings Above Regulated Return	$1,924	$3,475	($239)
50% of Earnings above Regulated Return	$962	$1,737	$0
PILS Grossed-up[11]	$347	$626	$0

With the foregoing revisions in hand, Hydro Ottawa is able to provide Table A below, which presents the utility's Earnings Sharing Mechanism ("ESM") calculations for 2016-2019.

[7] "Current year" means 2016 for the purposes of the column with information for 2016, and 2017 for the purposes of the column with information for 2017.
[8] Previous years' LRAM includes adjustment to any year not related to the current year.
[9] Current year LRAM includes adjustments in reporting years subsequent to the current year.
[10] Tax rate = 26.5%.
[11] Tax rate = 26.5%.

Table A – 2016-2019 ESM Calculations ($'000s)[12]

	2016	2017	2018	2019
Net Income (per RRR)	$33,483	$36,114	$34,605	$37,250
Deduct Previous Years' LRAM[13]	$(1,042)	$(1,081)	($482)	($1,322)
Add Current Year LRAM[14]	$773	$1,429	$411	$1,322
PILS Grossed-up on CDM Adjustments[15]	$(97)	$125	($26)	$0
Net Income after Adjustments	**$33,311**	**$36,336**	**$34,559**	**$37,250**
Deemed Equity (per RRR)	$341,540	$357,578	$378,652	$422,211
ESM Achieved ROE	9.75%	10.16%	9.13%	8.82%
Deemed ROE	9.19%	9.19%	9.19%	8.98%
% Return Above Deemed	**0.56%**	**0.97%**	**-0.06%**	**-0.16%**
Earnings Above Regulated Return	$1,924	$3,475	($239)	$(664)
50% of Earnings above Regulated Return	$962	$1,737	$0	$0
PILS Grossed-up[16]	$347	$626	$0	$0
RATEPAYERS' SHARE OF OVEREARNING[17]	**$1,309**	**$2,364**	**$0**	**$0**

[12] "Current year" means 2016 for the purposes of the column with information for 2016, 2017 for the purposes of the column with information for 2017, and so on.
[13] Previous years' LRAM includes adjustment to any year not related to the current year.
[14] Current year LRAM includes adjustments in reporting years subsequent to the current year.
[15] Tax rate = 26.5%.
[16] Tax rate = 26.5%.
[17] Totals may not sum due to rounding.

INTERROGATORY RESPONSE - CCC-79

CCC-79

EXHIBIT REFERENCE:

Ex. 9-1-3, p. 5

SUBJECT AREA: Deferral and Variance Accounts

Question(s):

Hydro Ottawa is proposing a symmetrical variance account to record the revenue requirement impact related to overspending or underspending in the utility's capital plan in the System Access category. The rationale is that these expenditures are not within Hydro Ottawa's control as they can be volatile and difficult to predict:

a) For the years 2016-2020, please provide the forecast and actual System Access costs;

b) Does Hydro Ottawa agree that this account would effectively allow for these costs to be passed through to customers regardless of the amounts?;

c) Does Hydro Ottawa agree that this would reduce the business risk of the utility?;

d) Why is Hydro Ottawa treating 2025 differently with respect to this account?

RESPONSE:

a) Please see UPDATED Exhibit: 2-4-1 Capital Expenditures Summary, Table 4, 2016-2020 Capital Additions vs. OEB-Approved. As can be seen in the historical trend, System Access spending driven by customers exceeded Hydro Ottawa's estimates for the 2016-2019 period.

For additional information, please see part (a) of the response to interrogatory OEB-185.

b) Hydro Ottawa agrees that this account would effectively allow for System Access costs to be passed to/from customers regardless of the amounts. However, Hydro Ottawa's proposal is intended to safeguard both the utility and customers on spending that is outside the control of the utility. Please see part (c) below for additional details.

The timing of any variance difference will be disposed of based on when this account meets OEB guidelines related to Group 2 Accounts.

c) System Access capital expenditures fundamentally take local distribution companies ("LDCs") outside of their own risk-based decision-making process, seeing as the *Electricity Act* requires LDCs to offer non-discriminatory and equivalent service for all customers in its territory.[1] System Access requires LDCs to take into consideration additional factors that are controlled by the customer. In addition, any System Access investment reduces Hydro Ottawa's cash flow available for other capital expenditures in System Renewal/System Service and General Plant.

This symmetrical variance account will ensure Hydro Ottawa can continue to provide value to ratepayers while not undermining the utility's ability to manage its invested capital prudently.

d) Please note the modification to the System Access Regulatory Account can be found in Exhibit 9-2-1: New Deferral and Variance Accounts.

Hydro Ottawa is only proposing to treat this account differently in 2025 vs. 2021-2024 in terms of clearance timing. This approach acknowledges that the 2025 variance will not be available at the time of Hydro Ottawa's next rebasing rate application.

[1] *Electricity Act, 1998* S.O. 1998 c. 15, Sched A, s. 28.