INTERROGATORY RESPONSE - SEC-21

1-SEC-21

EXHIBIT REFERENCE:

[Ex.1-1-1, Attachment B]

SUBJECT AREA: UMS Unit Cost Benchmarking Study

For each asset category and OM&A program/practice included in the UMS Study, please provide the total annual amount spent or forecast to be spent on each, for each year between 2016 and 2025.

RESPONSE:

Please see the response to interrogatory OEB-44 part (b).

INTERROGATORY RESPONSE - SEC-22

1-SEC-22

EXHIBIT REFERENCE:

[Ex.1-1-1, Attachment B, p.40]

SUBJECT AREA: UMS Unit Cost Benchmarking Study

On the same basis as the information required in Appendix F, 'Unit Cost Tab', please provide Hydro Ottawa's actual information for 2019, and the forecast information for each year between 2020 and 2025.

RESPONSE:

Please see the response to interrogatory OEB-44.

INTERROGATORY RESPONSE - SEC-23

1-SEC-23

EXHIBIT REFERENCE:

[Ex.1-1-1, Attachment B]

SUBJECT AREA: Benchmarking

With respect to the Gartner, Hydro Ottawa IT Budget Assessment Benchmark Report:

a) Please provide a copy of the retainer and any other instructions provided to Gartner.

b) Please confirm that for both 'IT Budget % of Revenue' and 'IT Budget % of 'Operating Expenses' metrics, Revenue and Operating Expenses includes cost of power. If confirmed, please revise the metrics to exclude cost of power costs.

c) [p.8] Please provide a list of the peer group companies.

d) [p.8] Of the 9 peer group utilities, how many are similarly distribution only utilities?

e) [p.27] Please provide a copy of Hydro Ottawa's IT Budget Assessment Model data.

f) Please reference and reconcile the IT spending data with historic IT spending information contained in the application.

RESPONSE:

As a preface to its response, Hydro Ottawa notes that "Exhibit 1-1-1 Attachment B" was referenced in this question. Hydro Ottawa has interpreted this interrogatory as pertaining to Attachment 1-1-12(F): Hydro Ottawa IT Budget Assessment Benchmark.

a) Please see Attachment SEC-23(A): IT Budget Assessment Benchmark - Statement of Work.

b) Yes, Hydro Ottawa confirms that page 7 of the IT Budget Assessment Benchmark states the following: "Revenue and operating expense include power recovery and cost of power in accordance with Gartner Benchmarking definitions." This is Gartner's standard practice when conducting benchmarking studies for utilities.

Table A presents the revisions to the two metrics, when cost of power is excluded from both Revenue and Operating Expenses.

Table A – Adjusted Metrics with Cost of Power Excluded

Adjusted Metrics (Excluding Cost of Power)	
IT Budget as a % of Revenue	11.7%
IT Budget as a % of Operating Expense[1]	22.5%

c) Please see the response to part (a) of interrogatory OEB-48.

d) Gartner confirms that all organizations within the peer group are electricity distributors.

e) Please see Table B and Table C below for the utility's IT Budget Assessment Model data to complement the information provided on page 7 of the IT Budget Assessment Benchmark.

[1] The numerator for this calculation consists of the IT Capital and Operating budget, while the denominator consists of the utility's total Operating Expense, with no capital expense included.

Table B – IT Operations ($'000s)

OM&A Category	2018 Costs
Labour Compensation and Benefits	$6,259
Program Costs (e.g. IT Subscriptions, Maintenance Contracts, Professional Fees)	$10,267
Occupancy and Support Costs	$466
TOTAL	**$16,992**

Table C – IT Capital ($'000s)

Capital Program	2018 Costs
System Service	
Station Enhancements	$9
Distribution Enhancements	$84
Grid Technologies	$3,666
General Plant	
Buildings - Facilities	$184
HONI Payments	$2
Customer Service	$38
ERP System	$104
IT Life Cycle & Ongoing Enhancement	$2,058
IT New Initiatives	$2,839
Operations Initiatives	$269
TOTAL	**$9,253**

f) The objective of the IT Budget Assessment Benchmark prepared by Gartner was for Hydro Ottawa to gauge its IT spending relative to peer utilities. Hydro Ottawa does not budget OM&A and capital expenditures based on the categories utilized by Gartner and is therefore not able to provide a breakdown of spending in the manner requested.

These categories, however, are part of a standard framework used by Gartner within the utility industry to perform peer group comparisons. Hydro Ottawa chose 2018 as the representative year and supplied Gartner with reasonable allocations of OM&A and

capital expenditures in the categories required for peer comparison under Gartner's methodology.

For IT spending information, please refer to other pieces of evidence in this Application, as follows:

- For IT OM&A, please see UPDATED Exhibit 4-1-4: Operations, Maintenance and Administration Cost Drivers and Program Variance Analysis, Table 10.

  Table D identifies the OM&A programs listed in Table 10 of UPDATED Exhibit 4-1-4 which primarily capture the IT OM&A spending that was benchmarked as part of the Gartner study.

Table D – OM&A Program Costs Associated with Benchmarked IT Spending ($'000s)

Programs	2018 Costs
Customer Billing[2]	$8,866
Information Management & Technology	$10,692
TOTAL	**$19,558**

- For information on IT Capital Expenditures, please refer to Exhibit 2-4-3: Distribution System Plan, Table 8.30. The applicable Investment Categories/Capital Programs are Customer Service, ERP System, IT New Initiatives, IT Life Cycle & Ongoing Enhancement, and Operations Initiatives.

[2] Customer Billing includes costs associated with Billing, Meter to Cash ("MTC") and Meter Data operations and staff. For purposes of the Gartner study only technology costs were captured from this category.

A Proposal to
Hydro Ottawa

IT Budget Assessment Benchmark

30 November 2018
Gartner Engagement Number: 330054500

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Gartner

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gartner.com

Gartner

30 November 2018

Mark Fernandes
Chief Information Officer
3025 Albion Road North
Ottawa, Ontario K1G 3S4

Telephone: 613-738-5499
Email: markfernandes@hydroottawa.com

Gartner Engagement Number: 330054500
Re: Proposal for IT Budget Assessment Benchmark

Dear Mr. Fernandes:

Gartner Canada Co. (Gartner) is pleased to provide Hydro Ottawa Limited (Hydro Ottawa) with this Proposal for an IT Budget Assessment Benchmark.

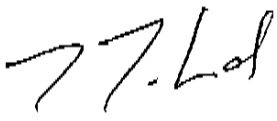
The assessment will include a comparison of high level IT metrics and spending and staffing distributions aimed at providing insight into how IT spending at Hydro Ottawa aligns with peer organizations.

If this Proposal represents your requirements, please sign the Authorization Page and return the entire Proposal to Nicholas Lal at nicholas.lal@gartner.com .

Please contact me at +1 416 228 7663 or via email if you have any questions regarding this Proposal. Thank you for this opportunity. We look forward to assisting Hydro Ottawa with this key initiative.

Our offer is valid for 30 days from the submission date of this Proposal.

Sincerely,



Nicholas Lal
Managing Partner, Gartner Consulting

cc: Karen Leggett, Senior Account Executive

Steven Lachowski, Executive Partner

Attachment

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The Gartner Advantage

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1.0 The Gartner Advantage

1.1 Introduction

Gartner is pleased to submit this Proposal to Hydro Ottawa for an IT Budget Assessment Benchmark. Not only is Gartner capable of meeting all the project objectives and meeting or exceeding all the evaluation criteria, we also believe we are uniquely qualified to support this critical initiative.

1.2 Gartner Approach

Hydro Ottawa is looking to assess its overall IT spending in terms of enterprise-level metrics and the distribution of IT spending. Gartner is proposing an IT Budget Assessment to enable Hydro Ottawa to better understand and compare IT spending within the organization. The assessments will include comparison and analysis of high level IT metrics and spending and staffing distributions, aimed at providing insight into how IT spending at Hydro Ottawa aligns with peer organizations.

To meet these objectives, Gartner proposes use of our IT Budget Assessment—an objective review which includes metrics relating IT spending and productivity to business revenue and income. With an IT Budget Assessment, Gartner uses enterprise-level metrics to provide insight into current strategic IT investment levels relative to business performance and scale versus the competitive landscape.

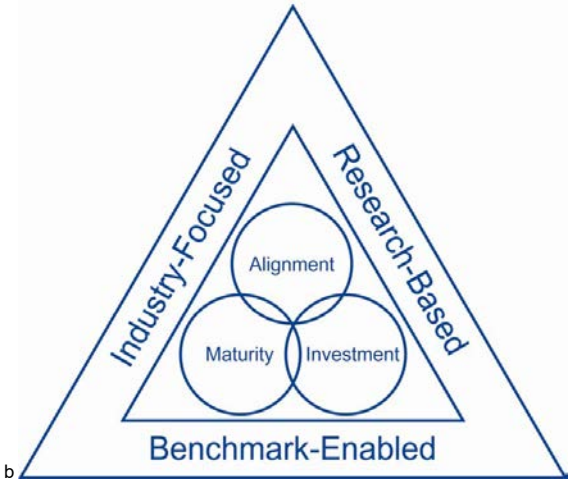
1.3 Unique Gartner Qualifications

1.3.1 Gartner Value

There is a reason that Gartner is quoted an average of 70 times per week in more than 30 leading business publications. There is a reason that more than 70% of the *Fortune* 1000 and 75% of the Global 500 support their key technology decisions with Gartner insight. And, there is a reason that our clients in more than 12,400 distinct organizations worldwide trust their organizations to Gartner. The reason is simple: Gartner delivers value to our clients every day. The cornerstone of the Gartner Value is that our solutions are research-based, industry-focused and benchmark-enabled, and our Consulting engagements deliver a comprehensive view that takes into account alignment, maturity and investment.

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Figure 1. Gartner's Unique Value



b

Gartner will deliver value for Hydro Ottawa, as demonstrated by the proof points in the following table.

Table 1. Gartner Value Proof Points

Gartner Value for Hydro Ottawa	Proof Points
Gartner Consulting Solutions Are Enabled By World-Class Benchmark Databases Our support leads to defensible business decisions because it is driven by our industry-leading benchmark data. We are the pioneers in IT benchmarking, and our database is the broadest, deepest and most up-to-date in the industry. With our benchmark data, we drive quantitative, measurable savings. Use of our benchmarking database and approach typically identifies more than double the savings identified through less rigorous methodologies.	■ Clients improve business performance by benchmarking their spending and best practices against our IT performance repository, the largest in the industry, drawing on more than 5,000 IT benchmarks a year. ■ Gartner has provided IT benchmarking services for more than 34 years, longer than any of our competitors. We are the founder of benchmark industry standards such as Total Cost of Ownership.
Gartner Is Independent and Objective Our advice is trustworthy and credible because we maintain strict objectivity and independence. Our strategic recommendations are driven by what is best for our clients, and not what is best for Gartner or any other company.	■ We have no preferred hardware or software vendors. ■ We do not perform implementation work so we are not concerned with downstream opportunities.

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Statement of Work

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2.0 Statement of Work

2.1 Project Tasks

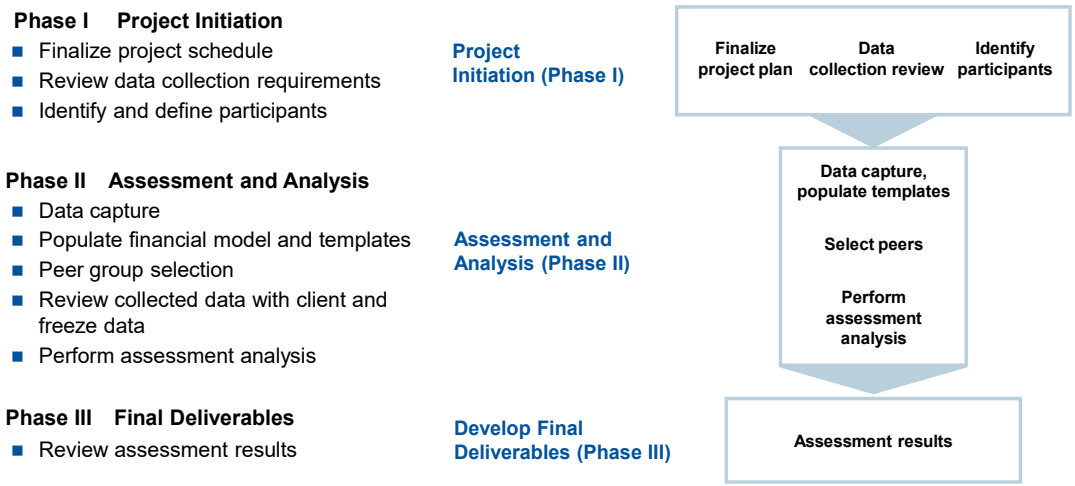
2.1.1 Detailed Approach

Gartner will construct a specific peer profile based on Hydro Ottawa's unique characteristics, revenue, industry and geography. Gartner will also take into account other attributes that Hydro Ottawa determines to be relevant.

Gartner will discuss data requirements with Hydro Ottawa and clarify data definitions. Where prudent, we will identify shortcuts to collect and validate the data for the required scope as quickly as possible. Hydro Ottawa will then submit summary quantitative data for IT spending and staffing, which will be validated by Gartner. We will discuss the criteria for selecting suitable peers with Hydro Ottawa and how we will deal with any Hydro Ottawa budget data that does not map directly to the Gartner definitions. All data used will be annual or annualized.

An overview of the Gartner Approach and Methodology for this engagement is shown in Figure 2 below.

Figure 2. Gartner Approach and Methodology



The IT Budget Assessment analysis will include business activity measures such as enterprise revenue, operating expense and employee count in relation to IT spending and staffing levels.

In addition, it is anticipated that the deliverables will include additional commentary and analysis to outline some of the unique impacts of union and other regulatory considerations on the results.

The IT functional areas in scope include:

- Applications development and support
- Enterprise computing and storage
- End-user computing
- IT service desk

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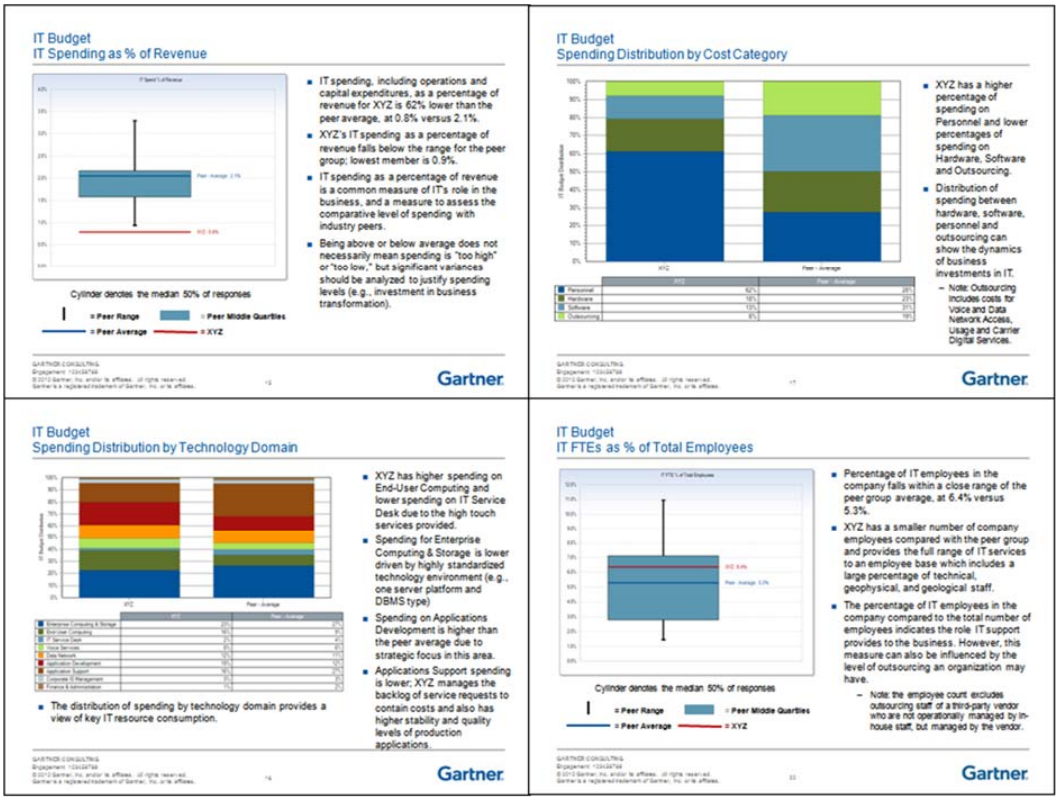
- Data networks
- Voice services

The IT Budget Assessment analysis will provide the following metrics:

- Spending Measures
  - IT Spending as a Percentage of Revenue
  - IT Spending as a Percentage of Operating Expense
  - IT Spending per Company Employee
  - Capital vs. Operational Spending
  - Run vs. Grow vs. Transform Spending
  - Distribution of IT Spending by Category (Hardware, Software, Personnel, etc.)
  - Distribution of IT Spending by Domain (Apps Development, Apps Support, etc.)
  - Revenue per Employee
- Staffing Measures
  - IT Staff as a Percentage of Company Employees
  - IT Contractor Usage
  - Distribution of IT Staff by Domain

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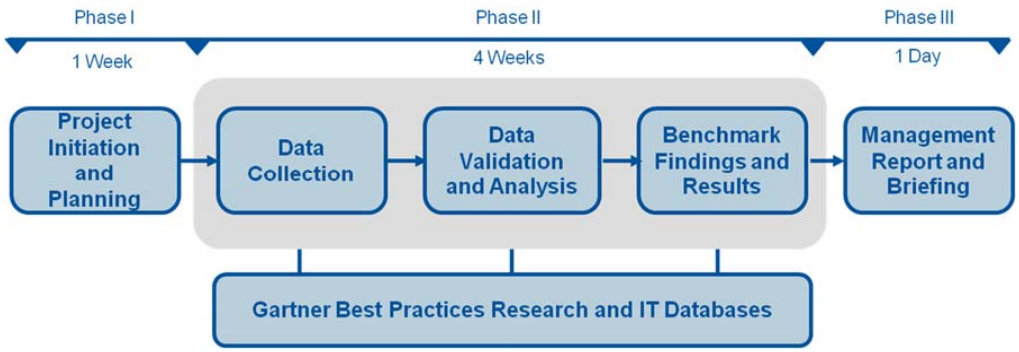
Figure 3. Sample Gartner Deliverables



2.1.2 Project Schedule

Gartner anticipates completion of this engagement within six weeks, as detailed in Figure 4. This schedule is dependent on the assumptions included in this Statement of Work.

Figure 4. Estimated Engagement Schedule



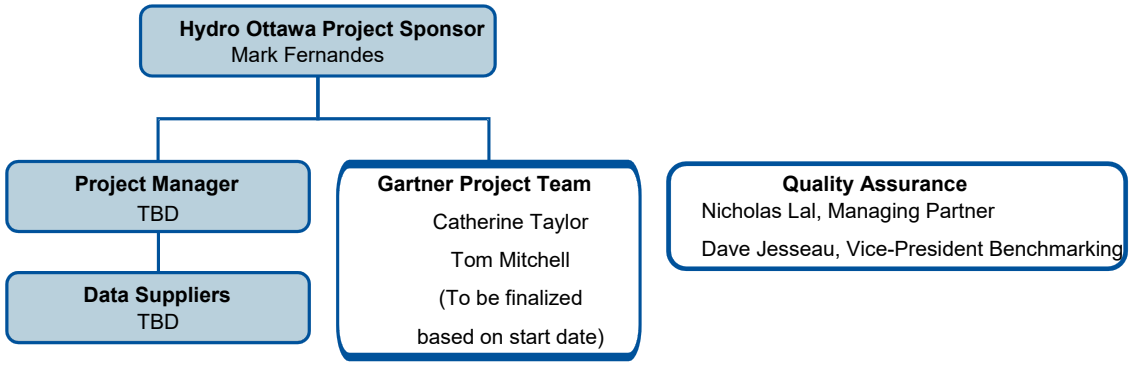
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2.2 Gartner Project Team

2.2.1 Project Team Organization

Gartner will create an organization structure for this engagement that ensures high-level sponsorship and quality assurance, strong day-to-day project management and deep subject matter expertise.

Figure 5. Project Team



2.2.2 Roles and Responsibilities

Gartner requires that the following roles with these defined responsibilities be identified within Hydro Ottawa.

Table 2. Hydro Ottawa Roles and Responsibilities

Role	Responsibilities
Project Sponsor	■ Confirm the objectives of the analysis ■ Ensure that we have the full commitment of Hydro Ottawa during the data collection and validation processes ■ Ensure that the results are acted on and used as agreed on by Hydro Ottawa ■ Attend the kickoff and management presentation
Project Manager	■ Identify contacts within the enterprise who are responsible for components of the required data ■ Ensure that Hydro Ottawa resources and data are made available in a timely manner ■ Ensure that the data is as accurate as possible ■ Ensure that Hydro Ottawa adheres to agreed-on timelines ■ Ensure that teleconferences are attended and scheduled appropriately ■ Be knowledgeable about the details of Hydro Ottawa's annual operating expenditures

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Role	Responsibilities
Data Suppliers	■ Populate the data collection tools with the necessary information to perform the benchmarking analysis ■ Be prepared to spend two to five days on data collection and validation, depending on the complexity of the enterprise and data repositories

Following is a description of the Gartner roles and responsibilities for this engagement.

Table 3. Project Team Roles and Responsibilities

Gartner Associate	Role	Responsibilities
Catherine Taylor Tom Mitchell	Project Team	■ Be responsible for the day-to-day management of project initiatives ■ Ensure that project deliverables are completed on time and meet the Gartner quality standards ■ Bring experience from prior Canadian utility benchmarks ■ Act as the primary point of contact for the Gartner team ■ Work closely with Hydro Ottawa to ensure that Gartner is meeting its needs ■ Work with Hydro Ottawa during data collection and validation to ensure that the data that Hydro Ottawa provides will enable a valid comparison with that of other enterprises ■ Perform the analysis against other enterprises in the Gartner database ■ Provide the results for the management presentation
David Jesseau	Quality Assurance Manager	■ Provide quality assurance review of Gartner project plan and Gartner deliverables throughout the engagement ■ Ensure value through use of the Gartner Project Management Life Cycle detailed in this document
Nicholas Lal	Quality Assurance/Client Relationship Partner	■ Responsible for the relationship with Hydro Ottawa and the overall client satisfaction on this engagement. ■ Provide review of Gartner business and technical advice and project deliverables. ■ Participate in key meetings and workshop, as required, throughout the engagement.

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2.3 Gartner Project Management Life Cycle

The Project Management Life Cycle Gartner uses for every engagement is based on our internal subject matter expertise and lessons learned, as well as external sources including the Project Management Institute's (PMI®'s) Project Management Body of Knowledge (PMBOK®) Guide. Gartner aligns with this globally recognized standard (ANSI/PMI 99-001-2008) to maximize value for our clients, minimize the risk for our clients' projects and ultimately ensure client satisfaction.

Figure 6. Stages of Gartner Project Management Life Cycle



Our approach is comprehensive — starting before the project kickoff and ending after the project close — to deliver results at every stage. The following table describes the typical activities, results and value provided by Gartner during the project management life cycle. However, it is important to note that Gartner views a project as an event that happens *with* a client — not *to* a client. We work closely with our clients to adapt leading practices to fit each client's environment and each project's requirements.

2.4 Assumptions

The deliverables, schedule and pricing in this Proposal are based on the following assumptions:

- All deliverables from this engagement shall not be utilized in discussions and/or negotiations with any external service providers for the purposes of measuring or evaluating the price efficiency of existing or proposed IT services contracts.
- All data collection and interviews/workshops will take place via telephone and e-mail or in person at Hydro Ottawa offices in Ottawa, Ontario, as described in this proposal and/or as agreed to at the project kickoff.
- Hydro Ottawa will provide data in an expedient and efficient manner according to project timelines, and will dedicate resources to the process of validating this same data with Gartner to ensure timeliness of the management report.
- Hydro Ottawa will assign a project manager to coordinate Hydro Ottawa activities, resources, and teleconference meetings.

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- Data collection support from Gartner will be provided via telephone and e-mail and shall not extend past a two-week period.
- Hydro Ottawa will review and approve documents within five business days. If no formal approval or rejection is received within that time, the deliverable is considered to be accepted by Hydro Ottawa.
- Any changes to data requested after the sign-off at the data freeze milestone is considered a change in scope (See Changes to Scope section of this Statement of Work).
- Hydro Ottawa's project sponsor has the authority, willingness and ability to prioritize, control and manage all personnel who are required to contribute data for the analysis and to ensure successful project completion within the designated time frame.
- Hydro Ottawa can arrange for the following key staff functions for up to four weeks of data collection activity (these key staff functions should include those individuals who are responsible for, or hold information about, the full scope of the assessment):
  - Financial analysts with full access to cost data relating to people and technology
  - Asset/inventory management staff with knowledge of the technologies that are used
  - Technology operations manager with full insight into how IT staff time is spent
- Any specific elements not defined as a part of the benchmark model are outside the scope of the benchmark. No requirement exists for any additional or special analysis for various divisions, sites, subgroups or other similar organizations inside the scope beyond one peer group and enterprise view of Hydro Ottawa data in comparison to that peer group.
- No requirement exists for client-customized data collection or data reporting processes. Standard Gartner procedures for technology assessments and presentations described in this Statement of Work will be used exclusively.
- Any requests for additional information (beyond the details described in the tasks above) that are made by Hydro Ottawa will be considered a change in scope for this engagement and will be handled accordingly (see Changes to Scope section of this Proposal).
- All deliverables will be developed in English using Microsoft products (for example, Project, Excel, Word and PowerPoint).

2.5 Investment Summary

2.5.1 Investment Overview

Gartner will conduct the Consulting tasks outlined in this Statement of Work for a firm-fixed price of $127,500 CAD, inclusive of travel expenses and exclusive of applicable taxes.

2.5.2 Invoicing

Gartner will bill for 50% of the professional fees at contract signing and 50% upon acceptance of the final deliverable. Travel for Gartner resources will be limited to the kickoff and final management presentation. All invoices are payable net 30 days from date of invoice. While we do not itemize billing for professional services, we agree and will comply with any reasonable requests for records substantiating our invoices.

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If Hydro Ottawa requires a purchase order (PO) number, please specify the PO number in the Authorization section and forward a copy of the PO, with this agreement, to name/address or fax of appropriate individual. Ensure that the PO includes all labor and travel expenses quoted in this Statement of Work. Any pre-printed terms on the PO that are in addition to or in contradiction of the terms of this agreement shall be inapplicable.

2.6 Contract Details

2.6.1 Validity Period

The Proposal, including the Statement of Work, is valid for 30 days from 30 November 2018.

2.6.2 Changes to Scope

The scope of this engagement is defined by this Statement of Work. All Hydro Ottawa requests for changes to the SOW must be in writing and must set forth with specificity the requested changes. As soon as practicable, Gartner shall advise Hydro Ottawa of the cost and schedule implications of the requested changes and any other necessary details to allow both parties to decide whether to proceed with the requested changes. The parties shall agree in writing upon any requested changes prior to Gartner commencing work.

As used herein, “changes” are defined as work activities or work products not originally planned for or specifically defined by this SOW. By way of example and not limitation, changes include the following:

- Any activities not specifically set forth in this SOW
- Providing or developing any deliverables not specifically set forth in this SOW
- Any change in the respective responsibilities of Gartner and Hydro Ottawa set forth in this SOW, including any reallocation or any changes in engagement or project manager staffing
- Any rework of completed activities or accepted deliverables
- Any investigative work to determine the cost or other impact of changes requested by Hydro Ottawa
- Any additional work caused by a change in the assumptions set forth in this SOW
- Any delays in deliverable caused by a modification to the acceptance criteria set forth in this SOW
- Any changes requiring additional research analyst time or changes to research analyst resources

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2.6.3 Authorization

This Proposal is submitted under the terms and conditions of the Master Agreement for Management Consulting Services dated June 16, 2018 between HER MAJESTY THE QUEEN in right of Ontario as represented by the Minister of Government and Consumer Services and Gartner Canada Co.

When signed by Gartner and Hydro Ottawa, this SOW is an attachment to and governed by the Master Client Agreement and Supplement between the parties. These documents will set forth the relationship between the parties for this engagement. This Statement of Work may be modified at any time provided such changes are agreed by the parties in writing.

SUBMITTED ON BEHALF OF GARTNER CANADA CO.

SIGNATURE

Nicholas Lal, Managing Partner
PRINT NAME AND TITLE

30 November 2018
DATE

AGREED ON BEHALF OF HYDRO OTTAWA LIMITED

SIGNATURE

PRINT NAME AND TITLE

DATE

PO NUMBER (IF APPLICABLE)

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2.6.4 Further Assurances

Gartner Research and Consulting recommendations are produced independently by the Company's analysts and consultants, respectively, without the influence, review or approval of outside investors, shareholders or directors. For further information on the independence and integrity of Gartner Research, see "Guiding Principles on Independence and Objectivity" on our website, gartner.com or contact the Office of the Ombudsman at ombudsman@gartner.com or +1 203 316 3334.

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Any questions regarding this Proposal should be addressed to:

Nicholas Lal
Managing Partner
Gartner Canada
1 Yonge Street, Suite 1600
Toronto, ON M5E 1E5

Telephone: +1 416 228 7663
Email: nicholas.lal@gartner.com

This Proposal was prepared for Hydro Ottawa:

Mark Fernandes
Chief Information Officer
3025 Albion Road North
Ottawa, Ontario K1G 3S4

Telephone: 613-738-5499
Email: markfernandes@hydroottawa.com

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Gartner

INTERROGATORY RESPONSE - SEC-24

1-SEC-24

EXHIBIT REFERENCE:

[Ex.1-1-1, Attachment G]

SUBJECT AREA: Benchmarking

With respect to the Mercer, 2019 Market Benchmarking Study:

a) Please provide a copy of the retainer and any other instructions provided to Mercer.

b) For each position benchmarked, please provide the number of Hydro Ottawa employees who hold that position.

c) Please provide a table that shows each element of compensation that can be paid to Hydro Ottawa employees, and what elements are included in the survey and what elements are not.

d) What time period is the Hydro Ottawa data based on?

e) [p.3] For each of the survey sources, please provide the peer group of companies/entities. (If Mercer is unable or does not know the peer group of companies/entities, please provide as much information as it has available to it(i.e. number of companies/entities, sectors, public and/or private sector, etc.).

f) [p.10] Please confirm that Mercer did not benchmark pension and employee benefit costs to the peer group companies and entities and the comparison made was to the Ontario public sector.

RESPONSE:

a) Please refer to Attachment SEC-24(A): Project Initiation Form - Total Compensation Program Review.

b) For each position benchmarked, Table A provides the number of Hydro Ottawa employees who hold that position.

Table A – Number of Employees for Benchmarked Positions

Positions	# of Employees
Manager, Distribution Operations	5
Supervisor, Distribution Operations	13
Distribution Engineer	8
System Operator	11
Network Administrator	5
Powerline Technician	64
Management Accountant	7
Communications Advisor	2
Supervisor, Billing & Collections	2
Senior Procurement Agent	3
Warehouse Attendant	9
IT Service Desk Technician	4
GIS/CAD Technician	12
Customer Contact Agent	7
Billing Service Associate	9

c) Table B below shows each element of compensation by group and the elements included in the study.

Table B – Compensation Elements Included in the Benchmarking Study

Elements	Union	Management	Included in Study
Base Salary	X	X	X
Incentive[1]		X	X
Overtime[2]	X	X	
Shift Differential[3]	X	X	
On Call[4]	X	X	
Responsibility Pay	X		
Acting Pay	X	X	

d) Hydro Ottawa's data was as of July 5, 2019.

e) Please refer to Attachment SEC-24(A): Project Initiation Form - Total Compensation Program Review and Attachment SEC-24(B): Hydro Ottawa Peer Group Breakdown - Total Compensation Program Review for the peer group of companies/entities by industry and sector, as it relates to the Canadian Mercer Benchmark Database Survey and Mercer Ontario Society of Professional Engineers National Engineering Survey.

With respect to the MEARIE data source, there were 41 participants from Ontario.

For management positions and non-management (unionized) positions, the number of benchmarked Local Distribution Companies ("LDCs") varied by position, from 8 to 60.

f) Hydro Ottawa confirms that Mercer did not benchmark pensions and employee benefit costs to the peer group companies and entities. Hydro Ottawa also confirms that the comparison made was to the Ontario public sector.

[1] Applies to Senior Managers only.
[2] Does not apply to Senior Managers.
[3] Applies only to Shift Supervisors.
[4] Does not apply to Senior Managers.

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Ms. Lyne Parent-Garvey
CHRO, Human Resources
Hydro Ottawa
2711 Hunt Club Rd.
Ottawa, Ontario
K1G 3S4
24 July 2019

Project Initiation Form (PIF)

Dear Ms. Parent-Garvey:

The objective of this Project Initiation Form (PIF) is to confirm the scope of our work and the professional fees for this project.

I. Project Details

1. **Client Name:** Hydro Ottawa
2. **Project Name or Services:** Total Compensation Program Review
3. **Our Understanding of your needs:** Hydro Ottawa is looking to engage a consulting firm to undertake a review of its total compensation program (defined as base salary, short-term incentives as applicable, insured benefits and pension) for unionized and management group roles in its regulated business, against relevant market comparators. This review is to be conducted as part of Hydro Ottawa's five-year rate application process.
4. **Description of Mercer Responsibilities:** Mercer will partner with Hydro Ottawa to complete the following:

1 – Project Start-up and Current State Assessment
Prior to conducting the compensation review, Mercer will review Hydro Ottawa's approach to total compensation and its current compensation structures (seven salary scales and steps that govern movement within for the unionized roles; and six salary scales for the management group roles).

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2 – Market Benchmarking
Hydro Ottawa will provide information from the annual MEARIE database that surveys various roles found in electricity distribution companies in Ontario. Mercer will use this information in combination with data from the Mercer Job Library to deliver a review of Hydro Ottawa's compensation and pay mix for its unionized and management group roles against relevant market comparators. In addition, Mercer will conduct an overall comparison of Hydro Ottawa's contribution rates for benefits and pension compared to standard offerings in the public and private sectors.
2 – Total Compensation Review
Hydro Ottawa will provide information from the annual MEARIE database that surveys various roles found in electricity distribution companies in Ontario. Mercer will use this information in combination with data from the Mercer Job Library to deliver a review of Hydro Ottawa's compensation and pay mix. We assume a maximum of 20 roles will be assessed.
3 – Reporting
Our reporting will reflect Hydro Ottawa's positioning against relevant market comparators and outline related findings.

5. **Description of client responsibilities**: Provide required direction and access to the necessary data, information and resources in a timely manner.
6. **Estimated period of time over which work will be performed**: We are able to begin our work for you immediately. To comply with the timelines of the regulatory process, we would complete all survey work and have a final, written report ready for the end of September, 2019. For administrative purposes only, we expect that this engagement will be completed by October 31, 2019.
7. **Core Mercer Team**: The core Mercer team will consist of Ian Cullwick, Partner, and Cynthia MacFarlane, Principal. Ian and Cynthia have worked with a number of Canadian utilities on similar compensation stragegy and benchmarking intitiatives. Key clients in this regard have included: Toronto Hydro, NB Power, SaskPower, SaskEnergy, Alberta Utilities Commission, and the City of Ottawa. More broadly, Mercer Canada has also provided recent and related compensation advisory services to EMERA and another major Canadian utility (2018-2019 – confidential). Cory Skinner and and Elizabeth Hennigar have provided pension and benefits advice and guidance to Hydro Ottawa on an ongoing basis, and will be called upon as required for this project. Finally, Mercer's Toronto team provided the compensation analysis for the Custom IR application submitted by Toronto Hydro Electric-System Limited in August 2018, and the Custom IR application submitted by Hydro One Networks in March 2017.

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II. Fee Structure

Our professional fees are estimated to be in the range of CDN $30,000 - $33,000. In addition to professional fees, we would invoice for approved travel at cost.

We appreciate your business and look forward to working with you on this project. Please acknowledge your agreement to the project terms by signing below.

Mercer (Canada) Limited		**Hydro Ottawa**	
Name:	Ian Cullwick	Name:	Lyne Parent-Garvey
Title:	Partner	Title:	Chief Human Resources Officer
Signature:	Ian Cullwick	Signature:	Lyne Parent-Garvey
Date:	July 24, 2019	Date:	July 24, 2019

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Hydro Ottawa

Peer Group Breakdown

20 May 2020

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Aggregate Peer Group

- The following tables highlight the aggregated peer groups used for the Canadian Mercer Benchmark Database (MBD) Survey and Mercer Ontario Society of Professional Engineers(OPSE) National Engineering Survey
- Note - Not all entities would be represented for each job, a full breakdown can be found in the appendix:

MBD

Industry Sector	Private Sector	Public Sector
Logistics	14	1
Other Non-Manufacturing	35	6
Insurance/Reinsurance	29	5
Services (Non-Financial)	35	25
Other Manufacturing	76	1
Health Care Services	3	3
Energy	109	15
Consumer Goods	49	0
Life Sciences	43	1
High Tech	32	1
Banking/Financial Services	32	3
Retail & Wholesale	44	0
Chemicals	7	0
Transportation Equipment	15	0
Total	**523**	**61**

OPSE

Industry Sector	Private Sector	Public Sector
Services (Non-Financial)	2	0
Energy	2	0
Transportation Equipment	1	0
Other Manufacturing	1	0
Total	**6**	**0**

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Appendix

Peer Group by Position

Appendix
Peer Group by Position

Distribution Engineer

Industry Sector	Private Sector	Public Sector
Other Non-Manufacturing	1	1
Services (Non-Financial)	8	1
Other Manufacturing	11	0
Energy	20	5
Consumer Goods	3	0
Life Sciences	2	0
High Tech	6	0
Transportation Equipment	2	0
Total	**53**	**7**

Network Administrator

Industry Sector	Private Sector	Public Sector
Logistics	1	0
Other Non-Manufacturing	5	1
Insurance/Reinsurance	2	1
Services (Non-Financial)	6	6
Energy	11	1
Consumer Goods	3	0
Life Sciences	6	0
High Tech	6	0
Banking/Financial Services	9	1
Retail & Wholesale	3	0
Total	**52**	**10**

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Appendix
Peer Group by Position

Communications Advisor

Industry Sector	Private Sector	Public Sector
Logistics	2	0
Other Non-Manufacturing	5	1
Insurance/Reinsurance	9	2
Services (Non-Financial)	4	4
Other Manufacturing	2	0
Health Care Services	0	1
Energy	22	5
Consumer Goods	6	0
Life Sciences	3	1
High Tech	5	0
Banking/Financial Services	9	1
Retail & Wholesale	8	0
Chemicals	1	0
Transportation Equipment	4	0
Total	**80**	**15**

Management Accountant

Industry Sector	Private Sector	Public Sector
Logistics	8	1
Other Non-Manufacturing	21	5
Insurance/Reinsurance	21	4
Services (Non-Financial)	15	9
Other Manufacturing	20	1
Health Care Services	1	0
Energy	78	7
Consumer Goods	22	0
Life Sciences	18	0
High Tech	14	1
Banking/Financial Services	16	2
Retail & Wholesale	20	0
Chemicals	6	0
Transportation Equipment	7	0
Total	**267**	**30**

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Appendix
Peer Group by Position
Supervisor, Billing & Supervisor Collections

FIN.09.005.M10

Industry Sector	Private Sector	Public Sector
Logistics	3	1
Other Non-Manufacturing	3	0
Insurance/Reinsurance	2	0
Services (Non-Financial)	3	1
Health Care Services	1	0
Energy	1	0
Consumer Goods	1	0
High Tech	1	0
Retail & Wholesale	2	0
Total	**17**	**2**

FIN.10.001.M10

Industry Sector	Private Sector	Public Sector
Logistics	1	0
Other Non-Manufacturing	1	0
Other Manufacturing	1	0
Consumer Goods	2	0
High Tech	2	0
Retail & Wholesale	2	0
Chemicals	2	0
Total	**11**	**0**

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Appendix
Peer Group by Position

Senior Procurement Agent

Industry Sector	Private Sector	Public Sector
Logistics	5	1
Other Non-Manufacturing	8	2
Insurance/Reinsurance	3	1
Services (Non-Financial)	12	12
Other Manufacturing	55	0
Health Care Services	2	2
Energy	47	9
Consumer Goods	28	0
Life Sciences	13	1
High Tech	13	0
Banking/Financial Services	2	0
Retail & Wholesale	20	0
Chemicals	3	0
Transportation Equipment	11	0
Total	**222**	**28**

Warehouse Attendant

Industry Sector	Private Sector	Public Sector
Logistics	1	0
Other Non-Manufacturing	1	1
Insurance/Reinsurance	0	0
Services (Non-Financial)	1	1
Other Manufacturing	6	0
Health Care Services	0	0
Energy	10	0
Consumer Goods	5	0
Life Sciences	8	0
High Tech	2	0
Banking/Financial Services	0	0
Retail & Wholesale	11	0
Chemicals	4	0
Transportation Equipment	2	0
Total	**51**	**2**

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Appendix
Peer Group by Position

Senior Procurement Agent

Industry Sector	Private Sector	Public Sector
Logistics	5	1
Other Non-Manufacturing	8	2
Insurance/Reinsurance	3	1
Services (Non-Financial)	12	12
Other Manufacturing	55	0
Health Care Services	2	2
Energy	47	9
Consumer Goods	28	0
Life Sciences	13	1
High Tech	13	0
Banking/Financial Services	2	0
Retail & Wholesale	20	0
Chemicals	3	0
Transportation Equipment	11	0
Total	**222**	**28**

Warehouse Attendant

Industry Sector	Private Sector	Public Sector
Logistics	1	0
Other Non-Manufacturing	1	1
Insurance/Reinsurance	0	0
Services (Non-Financial)	1	1
Other Manufacturing	6	0
Energy	10	0
Consumer Goods	5	0
Life Sciences	8	0
High Tech	2	0
Retail & Wholesale	11	0
Chemicals	4	0
Transportation Equipment	2	0
Total	**51**	**2**

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Appendix
Peer Group by Position

IT Service Desk Technician

Industry Sector	Private Sector	Public Sector
Logistics	2	0
Other Non-Manufacturing	2	1
Insurance/Reinsurance	8	0
Services (Non-Financial)	8	3
Other Manufacturing	3	0
Health Care Services	1	0
Energy	13	3
Consumer Goods	2	0
Life Sciences	4	0
High Tech	6	0
Banking/Financial Services	8	0
Retail & Wholesale	9	0
Chemicals	2	0
Total	**68**	**7**

GIS/CAD Technician

Industry Sector	Private Sector	Public Sector
Other Non-Manufacturing	1	0
Services (Non-Financial)	3	1
Other Manufacturing	2	0
Energy	1	0
High Tech	1	0
Total	**8**	**1**

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Appendix
Peer Group by Position

Customer Contact Agent

Industry Sector	Private Sector	Public Sector
Logistics	3	1
Other Non-Manufacturing	2	0
Insurance/Reinsurance	2	1
Services (Non-Financial)	3	4
Other Manufacturing	7	0
Consumer Goods	8	0
Life Sciences	6	0
High Tech	1	0
Banking/Financial Services	2	0
Retail & Wholesale	2	0
Chemicals	1	0
Transportation Equipment	2	0
Total	**39**	**6**

Billing Service Associate

Industry Sector	Private Sector	Public Sector
Logistics	7	0
Other Non-Manufacturing	2	0
Insurance/Reinsurance	3	1
Services (Non-Financial)	8	3
Other Manufacturing	2	0
Health Care Services	2	0
Energy	0	1
Consumer Goods	1	0
Life Sciences	1	0
High Tech	4	0
Banking/Financial Services	1	0
Retail & Wholesale	1	0
Chemicals	1	0
Total	**33**	**5**

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INTERROGATORY RESPONSE - SEC-25

1-SEC-25

EXHIBIT REFERENCE:

[Ex.1-1-13]

SUBJECT AREA: Productivity

Please provide details of all productivity and efficiency measures Hydro Ottawa has taken since its last rebasing application in 2016. Please quantify the savings.

RESPONSE:

Please see the response to interrogatory OEB-47.

INTERROGATORY RESPONSE - SEC-26

1-SEC-26

EXHIBIT REFERENCE:

[Ex.1-1-9, p.32; Ex.1-1-13]

SUBJECT AREA: Productivity

For each listed productivity and efficiency measure Hydro Ottawa plans to undertake between 2021 and 2025, please quantify the forecast savings per year, and detail how the savings were calculated.

RESPONSE:

Please see the response to interrogatory OEB-47.

INTERROGATORY RESPONSE - SEC-27

1-SEC-27

EXHIBIT REFERENCE:

[Ex.1-2-2, p.5]

SUBJECT AREA: Customer Engagement

Please explain what specific changes, if any, were made to the proposed capital plan and/or application after the Phase II customer consultation.

RESPONSE:

Utilizing the input from Phase I, Hydro Ottawa planners developed a draft plan that included an estimated baseline cost, and identified a number of investment areas where spending could be increased, or in some cases decreased, in order to align with customer needs and expectations.

In total, more than 19,300 residential and small business customers completed the Phase II customer engagement workbook. The results indicated that a strong majority of Hydro Ottawa customers supported either what was then included in the utility's draft plans, or an approach that would accelerate the pace of investment.

No major adjustments to the proposed capital plan and/or Application were made after the Phase II customer consultation. The results from the Phase II consultation confirmed the assumptions that were used in the preparation of the Distribution System Plan.

INTERROGATORY RESPONSE - SEC-28

1-SEC-28

EXHIBIT REFERENCE:

[Ex.1-1-13, Attach A]

SUBJECT AREA: Corporate Scorecard

With respect to the Corporate Productivity Scorecard, please provide 2019 actuals and 2020 targets.

RESPONSE:

A copy of the Corporate Productivity Scorecard which includes 2019 actuals and 2020 targets has been appended as Attachment SEC-28(A): 2019 Corporate Productivity Scorecard.

2019 Corporate Productivity Scorecard

	Measures	Description	2019 Target	2019 Actual	2020 Target	2019 Assessment	Notes
Labour Utilization	Productive Time	% of Billable Hours / Total Regular Hours	≥ 74%	72%	≥ 74%	X	Below target but on par with prior year. Over 3,000 hours reported on an administrative work order associated with relocation work to Dibblee and Hunt Club
	Labour Allocation to CAPEX	% of Labour Time on Capital Activities / Total Productive Time	≥ 60%	58%	N/A	X	Below target but on par with prior year. Shift from Capital to WFO due to flood mitigation work for Portage and mutual aid (Maine and HQ) (both of these are recoverable from HOL's perspective)
	Reg Labour Allocation to Mtnce & Admin	% of Labour Time on Mtnce & Admin / Total Productive Time	N/A	N/A	≤ 34%	N/A	New Measure introduced in 2020 to focus on Performance Management
	Average Sick Days per FTE (annualized)	Total Sick Days / Total Employees	≤ 6.0	7.8	≤ 6.0	X	Exceeded target and prior year. Long term sick leave accounts for 40%. We are above the Ontario average of 7.4 days but below the National average of 8.5 days
	e-Learning Training per employee (annualized)	Number of hours of e-learning / Total Employees	≥ 2.0	3.9	≥ 2.0	●	Surpassed target. Increase in e-Learning hours in 2019 from Rate Application Online Collaboration Tools (AO Docs and Gsuite), Cybersecurity, and Code of Conduct online modules.

OM&A	Bad Debt as a % of Total Electricity Revenue	Bad Debt / Total Electricity Revenue	≤ 0.12%	0.08%	≤ 0.12%	●	Surpassed target and at lowest level in 4 years. The reduction in bad debt is explained by improved AR aging and overall Fair Hydro Plan. Residential class greater than 90 days improved by 32% due to increased OESP (Ontario Electricity Support Program) enrolments, disconnection moratorium is not having an impact on bad debt.
Asset Efficiency	Technology Infrastructure Cost per Employee	(External IT support costs + computer hardware & software depn) / # of FTE	≤ $24.9K	$22.5M	≤ $25.8K	●	Surpassed target and prior year primarily due to decrease in depreciation from longer useful life for CC&B and ERP.
Profitability Metrics	EBITDA as a % Revenue *	EBITDA $ / Total Revenue - Hydro Ottawa Limited	≥ 54%	52%	≥ 52%	X	Below target and prior year. Lower EBITDA due to higher expenses (leak remediation costs and one-time facilities costs) and lower distribution revenue partially due to Accelerated CCA tax change with offset below EBITDA
	Inventory Turnover Ratio and Value	Cost of Materials Used / Average Inventory	≥ 2.00	1.62	≥ 2.00	▲	Below target but improvement from prior year. Results primarily due to deferral of capital projects - ordering inventory in advance of need - continue to work with project managers

INTERROGATORY RESPONSE - SEC-29

1-SEC-29

EXHIBIT REFERENCE:

[EB-2015-0004, Ex.D-1-4, Attach]

SUBJECT AREA: Corporate Scorecard

Please provide a revised version of the 'Balanced Productivity Metrics' scorecard included as part of Hydro Ottawa's 2016-2020 application with additional data for 2014-2019 actuals, and 2020-2025 forecast data.

RESPONSE:

The Balanced Productivity Metrics scorecard included in the 2016-2020 application was renamed to the Corporate Productivity Scorecard. The 2014-2018 results were included in Attachment 1-1-13(A): Productivity Scorecard in the original evidence submitted on February 10, 2020. Please refer to Attachment SEC-28(A): Productivity Scorecard for the 2019 Actuals and 2020 Targets. The Corporate Productivity Scorecard has not yet been populated with 2021 to 2025 forecast data.

INTERROGATORY RESPONSE - SEC-30

1-SEC-30

EXHIBIT REFERENCE:

[Ex.2-1-1, Attach A]

SUBJECT AREA: Facilities Renewal Program

a) [p.21] How many FTEs work in or are based out of, in each of: a) EC-1, b) EC-2/3, c) SC-1

b) [p.3] Please provide a high-level summary, including total bid cost, for each of the 4 bids received for the design build contract.

c) [p.3] Please provide details regarding the scope and type of the design build contract (i.e. what work was covered under the contract, was the contract a fixed-price, etc.)?

d) [p.18] Please provide further details regarding the Bank Street facility. What is the purpose of the facility, its size, and its potential sale value and on-going costs.

e) [p.40] SEC seeks to understand the differences in the various sub-components, as opposed to total cost, included in the estimates between the Quantity Survey Report and the final actual costs. Please provide a table showing a breakdown of the estimates in the Quantity Survey Report, and on the same basis, the final actual costs. Please explain any material differences in each category/sub-component.

f) [p.40] What percentage of the total final contract was made up of costs under the design build contract? How does that compare with the estimated costs?

RESPONSE:

a) Table A provides a breakdown of the number of administration and operations employees working out of each of the new facilities, as of June 30, 2019. Please note that the staffing numbers provided relate to headcount, as headcount more accurately reflects space usage needs.

Table A – Headcount by Location

	EC-1	EC-2/3	SC-1
Administration (Inside)	409	10	18
Operations (Outside)	63	77	76
TOTAL	**472**	**87**	**94**

b) The four pre-qualified bidders selected from the Request for Qualification ("RFQ") were eligible to participate in the Request for Proposals ("RFP"). Their RFP responses were evaluated in a three-stage process:

Stage I: Mandatory Requirements: Bidders had to satisfy all mandatory criteria to advance

a) Bid Security: Bid Bond and Agreement to Bond
b) Confirmation of Insurance(s)
c) WSIB Compliance and Good Standing
d) Financial Letter of Good Standing
e) Agreement to Hydro Ottawa's OHSE Management Program (ISN)

Stage II: Technical Requirements: Bidders were required to submit responses to stipulated technical requirements (below) and had to obtain a minimum 70% technical score (140 pts) to advance to the next stage.

Criteria covered:

a) Key Team Members
b) New Team Members (if different from basis of RFQ prequalification)
c) Team Organization
d) Project Management Approach
e) Schedule
f) Sustainability & Energy Efficiency
g) Design: Bidders were required to submit detailed design proposals, briefs and drawings as part of their submission (for sites and all buildings)
    i) Architecture & Planning
    ii) Engineering
    iii) Sustainability
    iv) Presentation

Stage III: Financial Proposal: The Bids were evaluated by an Evaluation Committee composed of Hydro Ottawa's executive staff, Project Manager, and technical subject matter experts (as advisors). The evaluation process was managed by Hydro Ottawa's Supply Chain unit and overseen by a Fairness Commissioner. The Successful Bidder was based on the combined highest overall score of the Technical and Financial results weighted on a 60/40 basis.

The technical results from Stage II are shown in Table B below, while the Stage III financial results are shown in Table C below. The successful bidder had both the highest technical score and the lowest financial bid.

Table B – Summary of Technical Scores from New Facilities RFP

Bidder	Available Points	Score
Bidder 1	321.5	264.50
Bidder 2	321.5	263.18
Bidder 3	321.5	236.75
Bidder 4	321.5	n/a Submission deemed non-compliant and not scored for technical criteria

Table C – Summary of Financial Results from New Facilities RFP

Bidders	Evaluated Max Bid ($)	Hydro Ottawa Cash Allowance ($)	Total Max Bid ($)
Bidder 1	$58,977,000	$6,402,600	$65,379,600
Bidder 2	$71,003,500	$6,402,600	$77,406,100
Bidder 3	$61,985,149	$6,402,600	$68,387,749
Bidder 4	Submission did not achieve the minimum 70% technical score threshold and was deemed non-compliant. Bidder did not advance to Stage III Financials (financial bid not opened per terms of RFP).		
Bidder 1 was the successful Bidder, achieving the highest technical score (best design) and the lowest financial price.			

c) The scope of the Design-Build contract was to design and construct all required buildings at both the East Campus (EC-1, EC-2, and EC-3) and South Campus facilities. This contract was a fixed price Design Build contract (Canadian Construction Documents Committee or "CCDC" 14) modified to adhere to Hydro Ottawa's specific contracting requirements. The scope of the work included the completion of the design for the sites and buildings to Hydro Ottawa's requirements, obtaining all requisite planning and construction approvals from authorities having jurisdiction, and the complete construction and commissioning of the facilities. The scope also required the Design-Builder to coordinate and integrate all Hydro Ottawa's furniture, technology, and security systems during the construction.

d) The Bank Street facility, totalling 55,969 sq. feet, is used for fleet maintenance and training services and also as office space for project work such as long-term software development projects. The training centre includes a variety of rooms which can accommodate 10 to 75 participants. Additionally, each room is equipped with technology and equipment to facilitate various training programs. Training programs include professional development, new product training, trades, and safety training. In addition to the various corporate training requirements, Bank Street also provides training facilities for Algonquin College's Powerlines Technician, Power Line Maintainers, and Power Cable Apprentices programs.

The fleet-related services and space capture the following:

- office space for scheduling and dispatching fleet repairs;
- indoor garage and maintenance facilities including service bays;
- equipment for fleet repairs and maintenance;
- parts warehouse;
- wash bay for fleet washing;
- small engine shop with fleet equipment storage;
- line toll repair/testing facility; and
- parking area for vehicles awaiting service.

The book value of the Bank Street site is $9.431M, as of December 31, 2019. As Hydro Ottawa has not had the property appraised, the current market value is not known.

Ongoing costs associated with the Bank Street facility are summarized in Table D below.

Table D – Bank Street Facility Ongoing Costs ($)

OM&A	2020 Bridge Year
Maintenance Programs	
Seasonal	$48,747
Electrical/Mechanical	$111,207
Safety	$26,185
Security	$12,526
Cleaning and Waste Management	$87,985
General	$30,879
Municipal Costs	
Electricity, Water, Natural Gas and Property Taxes	$283,955
TOTAL	**$601,484**

e) There are a number of factors that influence variances between a pre-tender estimate prepared by a Professional Quantity Surveyor ("PQS") and the actual final cost of any project. The primary ones are as follows:

- **Market Conditions:** These conditions include those at the time of tender (e.g. builder and sub-trade market demand and availability). Design-build procurements require an early selection of key trades (mechanical and electrical), which can either positively or negatively impact bid costs where the PQS report anticipates a minimum of three bidders for each trade. In addition, bidders must account for/absorb escalations or market fluctuations on materials, equipment, etc. over the duration of the contract, which may be different than the time of the issuance of the PQS report.

- **Bid Strategy, Innovation & Risk Provisioning:** In a design-build contract, bidders can innovate the design, means, and methods to execute the work (while remaining compliant), resulting in either positive and negative variances. Likewise, in a fixed price design-build contract, the bidders must profile the total risk of the project across the complete design and construction phases. This varies between bidders and can

greatly alter the initial and final costs.

- **Bidder Scope Interpretation:** As noted in the response to part (b) above, bidders are required to interpret the complete scope of work, which in a design-build contract is based on indicative design drawings with performance-based specifications/requirements. Bidders must then commit to a fixed price and a certain schedule for the work. Contractors assume contractual risk, which a PQS does not. Despite the PQS' expertise in quantifying all requirements, variations can, and often do, occur.

- **Changes to the Work:** Unforeseen or necessary changes to the scope of work during the execution of the contract alter the final cost of any construction project and cannot be anticipated at the time of initial estimation.

Please see Table E and Table F below for additional variance explanations by sub-components, in relation to the East Campus and South Campus, respectively.

1 **Table E – Quantity Survey vs. Final Costs: East Campus ($'000s)**

Sub-Components	Quantity Survey East Campus	Final Actual Cost East Campus	*Var ($)*	*Var (%)*	Explanation
Shell: Structural and Exterior Enclosure	12,856	$11,870	*$(986)*	*(8)%*	Market Conditions: improved trade pricing (preferred pricing)
Interiors: Partitions and Doors, Finishes, Fittings and Equipment	5,273	$4,330	*$(944)*	*(18)%*	Market Conditions: improved trade pricing (preferred pricing)
Services: Mechanical and Electrical	9,163	$13,922	*$4,759*	*52%*	Market Conditions: single trade coverage/elevated market demand (M&E) at time of tender. Scope Interpretation: M&E systems highest risk. Changes to the Work: power and mechanical changes required during execution.
Site Preparation and Ancillary Work	5,624	$6,566	*$942*	*17%*	Changes to the Work: contaminated soils/modifications to stormwater drainage
General Requirements and Allowances	7,356	$5,618	*$(1,738)*	*(24)%*	Bid Strategy: bidder was aggressive on internal costs and deferred work during winter thereby reducing costs.
TOTAL	**40,272**	**$42,306**	***$2,034***	***5%***	

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Table F – Quantity Survey vs. Final Costs: South Campus ($'000s)

Sub-Components	Quantity Survey South Campus	Final Actual Cost South Campus	*Var ($)*	*Var (%)*	Explanation
Shell: Structural and Exterior Enclosure	6,056	$4,453	*$(1,603)*	*(26)%*	Market Conditions: improved trade pricing (preferred pricing) Bid Strategy: prefabricated buildings and non-winter work
Interiors: Partitions and Doors, Finishes, Fittings and Equipment	1,489	$1,236	*$(253)*	*(17)%*	Market Conditions: improved trade pricing (preferred pricing)
Services: Mechanical and Electrical	4,071	$3,924	*$(147)*	*(4)%*	*Immaterial variance*
Site Preparation and Ancillary Work	3,540	$3,654	*$114*	*3%*	*Immaterial variance*
General Requirements and Allowances	3,315	$1,944	*$(1,371)*	*(41)%*	Bid Strategy: bidder was aggressive on internal costs and deferred work during winter thereby reducing costs.
TOTAL	**18,471**	**$15,211**	***$(3,260)***	***(18)%***	

f) Please see Table G below for the percentage of the design-build costs relative to the total final contract. The design-build costs represent the "hard" construction costs and exclude costs such as land, furniture, development fees, professional fees, overheads, and financing charges. The final actual design-build costs, as shown in Table G below, represent 75% of the total construction costs excluding land, interest, and overhead, while the estimate was 76%.

Table G – Design Build Costs as a Percentage of Final Contract ($'000s)

	Project Estimate Cost	Final Actual Cost
Cost Component		
- Land	$19,300	$19,495
- Construction [A]	$77,200	$76,527
Subtotal	**$96,500**	**$96,022**
- Interest & O/H		$3,522
TOTAL	**$96,500**	**$99,544**
Construction [A]	$77,200	$76,527
Design Build Cost [B][1]	$58,743	$57,516
% of Design Build Cost [B] / Construction [A]	**76%**	**75%**

[1] Included in Table 9 of Attachment 2-1-1(A): New Administrative Office and Operations Facilities.

INTERROGATORY RESPONSE - SEC-31

1-SEC-31

EXHIBIT REFERENCE:

[Ex. 1]

SUBJECT AREA: Internal Audit

Please provide summaries of all internal audit reports conducted since 2016, their findings, recommendations, and the status of any corrective action taken or planned to be taken.

RESPONSE:

In the sections below, Hydro Ottawa provides a summary of the key findings from the 16 internal audits that have been conducted since 2016. A summary of the corresponding recommendations, as well as the status of the related corrective actions, are provided in Tables A-O.

1. 2016 INTERNAL AUDITS

1.1. BILLING & COLLECTIONS

a) Management practices for billing and collection of electricity distribution revenue are effective. Distribution rates are captured accurately in Hydro Ottawa's customer information system (CC&B), along with pass-through and other components, including regulatory charges. Bills to customers are accurate, and payments from customers are recovered in a timely manner.

b) Enabling logic-based controls and embedding workflows within CC&B would ensure greater compliance with the intent of customer service policies and procedures.

c) Monitoring controls require strengthening, with regard to key institutional and large commercial accounts in particular. Reconfiguring and rationalizing some existing exception reports would also improve efficiency.

d) Greater rigour, on the principle of least privilege, is required in the regulation of user access and powers within the CC&B system.

Table A – Internal Audit of Billing and Collections - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should consider re-configuring the customer information system so that policy intent and system design are congruent. A direct interface between the online move forms via the Hydro Ottawa website and MyHydroLink and CC&B should be considered to eliminate the risk of human error associated with manual data entry. Also, mandatory fields and logic controls should be introduced in CC&B to prevent accounts from being established with invalid customer data, or without unique identifiers altogether.	Management update - Feb 2020 In progress - Move requests from lawyers, property managers and landlords transitioned to online form ensuring Hydro Ottawa collects required personal identifiers. Online self-update capabilities increased including obligatory review & update of profile data by customer. Target implementation date: Q2 2020
#2 Management should finalize the voltage exception report with Savage Data Systems in order to address any revenue leakage. Similarly, the high-low exceptions for large commercial customers should be refined and low-end thresholds for small commercial customers should be developed based on customer specific historical consumption.	Implemented
#3 Management should investigate the possibility of refining what CC&B identifies as billing exceptions. This would reduce the amount of “noise” that distract agents from actual errors and help preserve the knowledge of experienced personnel. CC&B should also be expected to process as many routine sanity checks as possible.	Implemented
#4 Management should review user access levels and increase restrictions as appropriate: i) Access to create, or remove a customer account should be restricted to the agents who process moves in the normal course of operations. ii) Access to view banking information should be restricted to users that require this information in the normal course of operations and limited exceptions should be clearly defined. Banking details for all other users should be concealed with asterisks. iii) Access to make transfer adjustments involving inactive accounts should be limited to the fewest number of users possible and transfer adjustments should be subject to the same level of scrutiny as customer refunds. iv) Access to update regulated rates in the production environment of CC&B should be “frozen” between scheduled rate changes. The possibility of an embedded workflow may also be worth considering.	Implemented

1.2. SUSTAINMENT CAPITAL PROGRAM

a) Practices relating to the planning, implementation, and control of sustainment capital projects are effective in meeting business objectives.

b) While the planning components of control are robust, there is a clear need for an estimating tool, backed by project management software, which would reduce the wide disparities observed in project-level estimates.

c) In consultation with Finance, the engineering and asset management group should develop an appropriate financial model, including standard work units and costing parameters for each asset category.

d) Management is developing a plan to address the gaps identified by an external engineering consulting firm; when completed, this is expected to strengthen Hydro Ottawa's engineering, asset planning, and asset management capabilities.

Table B – Internal Audit of Sustainment Capital Program - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should identify and implement a designated estimating tool, backed by a project management software to standardize the methodology used to prepare estimates. Management should consider automating the practices relating to change order requests, using the available functionality in C-55. Greater automation would eliminate procedural inconsistencies and accelerate the approval process.	Implemented
#2 Management should consider collaborating with Finance to develop standard work units and costing parameters by asset category. These financial models should be combined with engineering criteria to improve the quality and detail of milestone monitoring and reporting on projects.	Implemented
#3 Management should approve, and lend its full support to plans developed to implement the remaining METSCO recommendations. The benefits of doing so should be realized by both Hydro Ottawa's regulated and unregulated lines of business.	Implemented

1.3. PROCUREMENT (COMPLETED IN Q1 2017)

a) The rollout of a new procurement policy in 2013 appears to have had a positive impact in some key respects. The proportion of purchasing through competitive processes grew from 75% in 2013 to 85% in 2016, which is even more significant in terms of the dollar values transacted - $84 million through competitive purchasing in 2013 versus $275 million in 2016. Some key controls within Procurement are not robust enough, however, to support the policy directives.

b) A process has not been established for the systematic review of longstanding purchasing arrangements, so that they may be brought gradually in line with the requirements of the procurement policy.

c) Procurement's due diligence practices on vendors and bidders, whether upfront or on an ongoing basis, do not appear to be designed with a clear understanding of vendor-related risks.

d) For a number of historical reasons, most of which were not within the control of the Procurement unit, the risk that the vendor master database lacks integrity must be considered high.

Table C – Internal Audit of Procurement - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should develop a control framework which would allow the disciplined and consistent delivery of policy directives in respect of fair, transparent purchasing, favourable pricing and vendor performance assessment. In the immediate, a review of the so-called 'strategic alliances' would appear to be a priority, so that the related goods and services may be moved into a competitive purchasing process.	Management update 2017-2019 In progress - Management has identified preliminary items for re-competition and had them vetted by Standards. The process of re-competing these items is ongoing.
#2 Management should strengthen the control procedures for due diligence on vendors, both upfront, and on an ongoing basis. Specifically, upfront procedures may be improved through a vendor due diligence checklist that would include reviews of whether the vendor: Is a legitimate company (e.g. vendor has a valid Ontario business identification number) Is properly licensed to operate (e.g. review regulator lists of debarred firms) Is financially stable (e.g. a review of the vendors financials or Dun & Bradstreet rating) Is offering competitive terms (e.g. rates and service levels are comparable to appropriate market benchmarks) Is organized for success (e.g. site visits as appropriate) Ongoing due diligence procedures may be improved through formally documented reviews of rates and service levels relative to industry benchmarks, and whether key vendors are expected to continue as going concerns.	Implemented

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
#3 Management should ensure the new ERP system is configured with the appropriate system based controls, including logic controls and mandatory fields. The plan for "scrubbing" the existing vendor master database prior to migration to the new ERP system should be considered a priority. Management also needs to develop a plan for the management and governance of the vendor master database, with appropriate consideration of the principles of least privilege access, restricted powers to access and edit master data, segregation of duties, audit logs, and change management. Internal Audit would support restricting powers to access and edit the vendor master data to staff within Procurement.	Implemented
#4 Management should require that Distribution Engineering & Asset Management communicate changes in the timing and/or inventory requirements of a project so that inventory "due dates" may be factored into purchasing decisions. To support this exercise, management may want to provide visibility to users on lead times and re-order points. For its part, Supply Chain should review its practice of transferring prematurely ordered inventory to a work order, although the equipment is still in storage. Management should address the functionality limitations of JDE in the new ERP system to allow further analysis of how long inventory items remain in storage.	Implemented

1.4. DISTRIBUTION SYSTEMS & ASSET MAINTENANCE - FOLLOW-UP (COMPLETED IN Q1 2017)

a) Management has addressed with purpose three recommendations made by Internal Audit in October 2014. The steps taken indicate widespread organizational effort, consultation and buy-in. As a result, Hydro Ottawa is significantly better placed now to close longstanding gaps and inconsistencies in information relating to its testing, inspection and maintenance ("TIM") programs.

b) The Asset Condition Assessment / Asset Investment Plan roadmap defines the centrality of TIM data to the development of short-term and long-term asset management plans. Upon completion, the roadmap will ensure consistent computation and application of asset 'health index' and thus leverage the asset analytics capabilities of Hydro Ottawa's asset planning system. Key procedures and practice advisories have been updated and published, along with a Nomenclature for equipment identification.

c) A consolidated budget document provides detailed guidance on budgetary provisions for each program and category of assets, along with clarity on the related projects, work orders and components. Accordingly, financial analysis and reporting appear to have gained in quality and granularity.

d) In the light of these control improvements, and in view of an ongoing exercise to align with ISO 55000 Standards, Internal Audit no longer sees the need to maintain its 2014 recommendation for the development of a TIM policy.

Table D – Internal Audit of Distribution Systems & Asset Maintenance - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1: In parallel with the investments and improvements noted earlier, management should devise an information management plan that would ensure: (a) consistency in nomenclature for TIM-related information across all applications and platforms; (b) discipline in capturing time and effort spent on TIM-related activities, followed by timely closure of work orders; (c) clear and verifiable coverage plans and schedules for external contractors as well as in-house teams; (d) clarity in the design of information flows from testing and inspection activities to enable centralized analysis and decision support for replace / repair decisions; (e) regular updates of asset-related information, including TIM activities to the relevant databases (GIS; PowerDB); (f) restoration of the link from the Hydro Ottawa website to the vegetation management page, which would enable optimization of resource deployment for vegetation management.	Implemented
#2: Management should establish specific – and feasible - annual targets, metrics and timelines for each program of the TIM plan, with appropriate consideration of the delivery mechanisms adopted for each program	Implemented

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
(fully in-house; fully outsourced; partly outsourced), the funds budgeted, and the resources committed. Escalation procedures, monitoring controls, and senior management review should be strengthened accordingly.	
#3: Management should develop a TIM policy that would allow planning objectives to be implemented. Perhaps, as discussed at the conclusion of our audit, TIM policy directives can be incorporated within an overarching policy on Asset Planning and Management.	No longer applicable
#4: As part of the TIM policy, management should define the criteria and timelines for periodic review and refreshing of work practice procedures and technical advisories.	Implemented

2. 2017 INTERNAL AUDITS

2.1 IT ASSETS & INFRASTRUCTURE

a) Management practices for the planning, acquisition, commissioning and management of IT assets and infrastructure are effective.

b) Availability of the corporate network and critical business systems exceeds performance benchmarks. Security packages and updates are applied rigorously, and maintenance is conducted in accordance with plans.

c) Management proposes to deploy part of its new Enterprise Resource Planning ("ERP") platform (JD Edwards v9.2) through an infrastructure-as-a-service. Efforts to ensure compliance with corporate security standards are expected to be completed by go-live date (January 2018).

d) Procedural controls need strengthening in a few areas, such as assigning accountability for assets to individual users, reconciliation of asset data with the physical location of assets, and periodic reviews of physical access to data centres.

Table E – Internal Audit of IT Assets & Infrastructure - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Prior to the ERP go-live date, management should ensure that the entry/exit point between Soft-layer and the Internet is closed. We note management's assurance that these steps will be completed before ERP go-live date (January 2018), and look forward to receiving confirmation thereof as and when applicable.	Implemented
#2 Management should consider "scrubbing" the existing asset information stored in Track-It! This could include obtaining confirmation from users on the assets they have in their possession. Regular physical inventory counts of IT assets should also be conducted to confirm the existence and whereabouts of IT assets. Anomalies identified through this process should be investigated in a timely manner and Track-It! should be updated as necessary	Implemented
#3 Management should consider "scrubbing" the existing asset information stored in Track-It! This could include obtaining confirmation from users on the assets they have in their possession. Regular physical inventory counts of IT assets should also be conducted to confirm the existence and whereabouts of IT assets. Anomalies identified through this process should be investigated in a timely manner and Track-It! should be updated as necessary. The IT infrastructure section should also ensure that the exit process is strictly enforced; specifically, that portable devices are returned to IT as inventory until they can be assigned to another user. Doing so may reduce the number of "umbrella" users and increase accountability.	Implemented
#4 Management should reinstate periodic reviews of physical access privileges to the IT data centres. The frequency of these reviews is at the discretion of management, although additional reviews may be warranted during periods when the volume of new users is high (e.g. summer hiring season). Alternatively, IT Infrastructure could request to be notified every time Facilities adds a user to a group with access to the IT data centres. Doing so would allow for more timely detection of inappropriate access privileges.	Implemented

2.2 TREASURY & FINANCING ACTIVITIES

a) Control procedures within the Treasury function are functioning as designed and are effective in meeting business objectives.

b) Long-term financing arrangements are backed by appropriate analyses and approvals. Short-term credit facilities and the related drawdowns are reasoned, and supported with the requisite documentation and approvals. Compliance filings are completed accurately.

c) Key control procedures, including bank reconciliation, are completed in a timely manner. No exceptions were noted in Internal Audit's transaction testing.

d) Internal Audit has recommended that the long-term funding model should be complemented with a financial risk evaluation tool.

e) (Removed: Item related to entities other than Hydro Ottawa Limited)

Table F – Internal Audit of Treasury & Financing Activities - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Not applicable: recommendation related to entities other than Hydro Ottawa Limited.	Not applicable
#2 Not applicable: recommendation related to entities other than Hydro Ottawa Limited	Not applicable
#3: Management should assign user access privileges in online banking portals in accordance with the principle of segregation of duties. If certain key security features are not available, e.g. two person authorization or email notifications to super-users when there are changes to a user's entitlement rights, management should adopt detective controls to compensate. These may include review of activity / audit logs regularly (i.e. monthly) to verify that user access privileges are reasonable and have not been modified unknowingly.	Implemented

2.3 EMERGENCY RESPONSE & BUSINESS CONTINUITY MANAGEMENT (COMPLETED IN Q1 2018)

a) Hydro Ottawa has a robust framework for business continuity, which should enable an effective response to emergencies or business disruption. Completing the planned Business Impact Assessments, establishing a rigorous schedule of exercises, tests and drills for all components of the framework, including key information systems, and a focus on preparedness for non-electricity crisis scenarios, should greatly enhance the effectiveness of the business continuity management program.

b) *(Removed: Item related to entities other than Hydro Ottawa Limited)*

Table G – Internal Audit of Emergency Response & Business Continuity Management - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should complete the business impact assessments expeditiously, at least in respect of 'Mission Critical' processes. Perhaps in-person, facilitated sessions with the frontline groups concerned would lend the requisite sense of urgency and allow quicker turnaround. The status of completion of BIAs should be a standard review item on the Business Continuity Management Steering Committee's agenda	Implemented
#2: Management should consider expanding its emergency response and business continuity exercise regime to assess the operating effectiveness of planned response mechanisms. This may include fully functional tests of processes, equipment, and infrastructure (e.g. call-out procedures / mass notification systems, failover capabilities for Class A systems, etc.). Training for plan owners on exercise design, and/or the development of an exercise design guide may also be beneficial. Life safety plans should be introduced for the work centre at Carling Ave.. Annual life safety exercises should cover all scenarios included in the life safety plans. Alternatively, if exercises are deemed impractical, mandatory training on the emergency procedures for the other scenarios should be completed on a regular basis. Creating these mechanisms now should stand the organization in good stead when it moves to its new locations in 2019. Management should also consider triaging the lessons learned from each exercise in a timely manner. A systematic approach to tracking the status of each item should also be implemented.	Management Update - Feb 2020 In progress - Everbridge, the employee notification system and a number of disaster recovery plans successfully tested. Manual tracking of actions resulting from exercises to be migrated to Cority, Hydro Ottawa's new Health, Safety, and Environment software solution. Work underway on: (i) developing an exercise design guide for plan owners, together with training; and, (ii) complementing fire / building evacuation drills with exercises incorporating identified threat scenarios. Target implementation date: Q4 2020
#3 Preparedness for non-electrical emergency scenarios requires attention	Management Update - Feb 2020 In progress - An exercise framework, including a number of non-electrical emergency / business continuity scenarios completed. A scenario for breach or theft of sensitive information assets & plan for drills/rehearsals underway. Target implementation date: Q4 2020
#4 Not applicable: recommendation related to entities other than Hydro Ottawa Limited	Not applicable

3. 2018 INTERNAL AUDITS

3.1 MANAGEMENT PRACTICES RELATING TO DISBURSEMENTS

a) Internal Audit's transaction testing indicates that the processing of disbursements is rigorous, consistent with the intent of corporate policies and procedures, and generally reliable. The exceptions we noted were not material, and could be attributed in the main to data anomalies in related JDE modules, such as the vendor master.

b) The internal control environment at present is perhaps excessively dependent on the people factor. Management could derive a considerably higher degree of assurance on the processing of disbursements with a more clearly defined approach on the governance of the ERP solution, including a focus on the security of information.

c) Internal Audit's suggestions for control improvement include a configuration change, to address the aggregation of powers with some staff, a few improvements to the newly rolled out expense management module, and the commissioning of some available functionality in the vendor master database.

Table H – Internal Audit of Management Practices Related to Disbursements - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should formalize the approach it wishes to take on the governance of the ERP platform. The mandate and deliverables should be set by the Executive Management Team. We would suggest a two-tiered approach in this regard: • an ERP Leadership Group, comprising senior managers in the CITO, CHRO, CFO and CEDO Divisions, whose key deliverables would relate to planning and investment / development of the ERP platform, while ensuring oversight of the system's performance, resilience and compliance with key tenets of the internal control framework, including review of Service Organization Control2 reports for key vendors; • an ERP Operating Group, comprising members of the Enterprise Applications Support team, as well as business leads from the key user groups, whose key deliverables would be ensuring the system's day-to-day performance, change management, user account management, testing system resilience, and executing key internal control procedures in a consistent and auditable manner.	Implemented
#2 Management should ensure that, in keeping with standard practice, the authority to receive services in the system should be reserved to the appropriate approval authorities in the business units. This privilege should be revoked from the AP Associates. We recognize that implementing these changes in control design might entail some effort and costs, but would believe them to be necessary.	Management Update - Feb 2020 In progress - A pilot project of Esker's accounts payable automation software to begin in Q2, 2020. Changes to the existing workflow to improve the related control design will be considered during the project. Target implementation date: Q1 2021
#3 Management should consider the following control improvements to enhance the security of employee, vendor and customer information across the ERP platform and its interfaces: • Vendors: Encrypt the file when it is created; alternatively, put in place an automated interface to send the file to Scotiabank, which would no longer require manual intervention by the AP supervisor. • Employees: Establish a process to review all newly created or modified user accounts in JDE, to confirm that the assigned roles would only allow an employee to view their own SIN.	Implemented

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
• Customers: Retire the report which provides access to all end-users to view customer bank account numbers in the Hydro Ottawa Customer Care & Billing (CC&B) application. Instead, perhaps the Supervisor Regulatory Accounting should be granted application level access within CC&B, so that she can confirm that Customer Service agents have correctly entered the information in CC&B.	
#4 Management should ensure JDE v9.2 is configured with the appropriate system based controls, including logic controls and mandatory fields. Streamlining the vendor database would reduce the likelihood of duplicate payment processing. A systematic review of the existing vendor master database should also be conducted regularly so that duplicate accounts, or long-inactive accounts, are deactivated / frozen. To assist with this review, management may consider running the A9-1 JDE v92 - Check for Address Book Duplicates report. Similarly, JDE v9.2 could be configured with additional searchable fields (e.g., postal code) to manually detect duplicate vendors, prior to the creation of a new account.	Implemented
#5 The following actions have been undertaken by management to address the limited data entry validation in the JDE expense module: A series of reports have been created to validate expense reports for mismatched information prior loading into the AP module to reduce the re-work required by AP associates. The JDE v9.2 job aid for Create Expense Report is being reviewed and updated to include more information on charge to types and expense categories. Videos, available on HydroBuzz, are being created to walk employees through creating an expense report in JDE v9.2 Management may also want to consider if an aging report can be created in JDE to determine which employees have not performed their credit card statement reconciliation by the 10th business day of the month. Management may also want to consider amending the Hydro Ottawa Corporate Policy for Credit Cards (POL-Fi-001.01) to indicate that a corporate credit card may be revoked if an employee does not reconcile their credit card statements as per the Hydro Ottawa Credit Card Reconciliation Procedure (PRO-Fi-010.00).	Management Update - Oct 2019 In progress - Significant progress made on the expense management module in terms of working with employees that were delinquent on submitting their expense reports or those with a high error rate, by Q3 2019 – the improvements were quite notable in terms of reduced error rate and limited backlog of unreconciled transactions – process and report developed to track this status monthly. With respect to policies and procedures – these updates have not been completed as of yet. With respect to delinquent balances notifications – have worked with IT to see if this could be implemented but the tools upgrade is necessary before we can implement this in the system – tools upgrade should occur in Q1 2020.

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
#6 Purchase orders initiated after-the-fact: Management should consider reporting the summary statistics on after-the-fact purchase requisitions using actual transaction dates rather than relying on employees to self-report instances on policy non-compliance. If this is not feasible, then management should consider making the category code 01 field mandatory with a default of "XXX Delinquent PO (After Invoice)" for a more conservative view of policy non-compliance. If JDE v9.2 cannot be configured to support multiple routing options then management should consider providing Divisional summary statistics to each sponsoring Executive separately. 2-and-3 way match tolerance limits: Management should consider adding a reasonable monetary ceiling to the 5% tolerance. JDE v9.2 supports simultaneously having a percentage tolerance and monetary ceiling, although only the percentage tolerance has been commissioned to date. Petty cash: Recommendation relating to other entities, not applicable. Vendor balances confirmation and reconciliation: Management should establish a procedure for confirmation of balances with key vendors, and a review process to investigate any discrepancies.	Management Update - Oct 2019 In progress - Purchase orders initiated after-the-fact: Management continues to monitor and report on known "after-the-fact" purchases with the appropriate escalation in approvals. These instances are reported quarterly to the Director, Finance and CFO, current consideration being given to how and in what level of detail to provide to other divisions. 2-and-3 way match tolerance limits: This has been implemented Petty cash: Recommendation relating to other entities not applicable. Vendor balances confirmation and reconciliation: AP staff do routinely review vendor statements of most key vendors, but they are reviewing for old invoices on the statement to follow up with. They are not doing full statement reconciliations. Also, while this is happening most months, it is subject to available time so for example during very busy times such as an audit, this task would be one that gets put aside until workloads normalize.

3.2 PLANNING PROCESSES FOR RE-BASING ELECTRICITY RATES

a) Management has laid a fairly robust foundation for the Custom Incentive Rate-setting application process. Organization-wide mobilization is well under way, with the constitution of a Working Group and a Steering Committee.

b) Management has recognized the state of flux in electricity sector policy in Ontario, and the potential for fundamental changes to the regulatory model that might be announced before the planned December 2019 submission of Hydro Ottawa's Custom IR application.

c) The key documents for rate planning have been appropriately identified. The timelines set for completion, review and final submission may prove somewhat challenging. A particular focus may be required on some pieces that the Ontario Energy Board deems critical to a successful rate application, notably the LDC business plan, the Distribution System Plan, and benchmarking analyses.

Table I – Internal Audit of Planning Processes for Re-basing Electricity Rates - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 In the light of management's decision to submit Hydro Ottawa's Custom IR application by December 2019, we would recommend particular attention be given to the expeditious completion and finalization of the foundational documents, i.e. HOL Business Plan, Detailed Planning Assumptions, Rate Case Strategy and the Financial Reference Base. We believe the completion deadline for these documents should be brought forward to the end of Q1 of 2019. That would leave sufficient time for scenario development and for appropriate rigour in the preparation and review of exhibits. We defer to management's current assessment that a dedicated project manager should not be retained for the Custom IR application. We would nonetheless urge a reconsideration of that stance should circumstances change.	Implemented
#2: While agreeing with actions and decisions taken until now by management, we would recommend that: • Management should continue to develop and update scenarios under all three rate-setting methodologies, in order to preserve maximum flexibility for the 2021-2025 rate cycle; • Management should consider developing the rationale, analyses and exhibits for the facilities renewal file a priority.	Implemented

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
#3: Management should consider aligning the Distribution System Plan with the OEB's revised filing requirements a priority. Management should also consider adding criteria for the evaluation of DER projects, potentially with financial models on how the related costs and investments could be absorbed, either by individual customers, or by ratepayers at large.	Implemented
#4 Management should define, without delay, the list of benchmarking exercises to be executed for the Custom IR application. The benchmarking exercises identified should be reviewed and approved by the Rate Application Steering Committee. The Regulatory Affairs group should set deadlines for the completion of each benchmarking exercise, to allow sufficient time for review, consistency in presentation, and appropriate integration in exhibits. In addition, management should establish and uniquely name each benchmarking exercise in a deliverable register. A process should be implemented to follow up on updates from the RAWG members on the status of benchmarking exercises.	Implemented

3.3 PAYROLL PROCESSING

a) Management's selection of Workday as its software-as-a-service solution for human capital management, including payroll processing, appears to be sound. A particular source of assurance is that control by design is integrated in several of Workday's key functionalities.

b) There is an opportunity to build a robust control framework atop Workday's control and product features. Internal Audit has recommended that management establish a set of foundational governance practices, where we observed some gaps at the time of our audit. A focus on standardization of exception reports, with appropriate thresholds, should also yield control benefits.

c) Internal Audit has suggested that payroll fund transfers should be effected through a more robust interface with Scotiabank, unlike the current interface, which the bank no longer supports.

Table J – Internal Audit of Payroll Processing - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should conclude the improvements it has begun on addressing gaps in governance practices specific to the Workday system: o Interface diagram o Enhancement requests list o Defects list (with status information) o Documentation of user access changes o Exception report standardization Procedures should be established for the periodic refreshing and review of these standard system governance documents. This exercise may also assist the organization at large in formalizing its governance model for the ERP platform, which comprises Workday and JDE.	Implemented
#2 Management should ensure that the controls in place to protect the security and privacy of employee data transferred as part of the integration structure between Workday and JDE are functioning as intended.	Implemented
#3 Management should consider moving to the fully supported ScotiaConnect software to transmit the compensation EFT file to the bank. ScotiaConnect is the standard software in use for banking operations in the CFO Division. To ensure the integrity of the compensation EFT file created from Workday, management may want to consider encrypting the file when it is created, or putting in place an automated interface to send the file to Scotiabank, which would no longer require manual intervention by the Payroll Advisor. In the interim, as these changes may not be quick to implement, management should: • Have the Payroll Advisor manually remove after each EFT file transmission the back-up files automatically created on her laptop; • Investigate encrypting the Payroll Advisor's laptop to prevent access to sensitive employee information contained in the EFT file in the event her laptop is stolen; These could complement the regular reviews of access to the shared drive where historical compensation EFT files are kept.	Implemented

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
#4 To further utilize the exception reporting functionality available in Workday, management should refine and expand its exception reports at both the employee level and for aggregate pay. A future-state could perhaps incorporate exception reports by pay type. Periodic headcount verification would be another target for management. People leaders may be well suited to this task. Management should investigate whether payroll inputs processed by the Payroll Advisor could be approved prior to the processing of payroll. At a minimum, a report of the payroll inputs processed for a given pay period should be reviewed for reasonableness after-the-fact. The ability of the Payroll Advisor role to edit and approve time in Workday on behalf of Supervisors should be on an exception basis only and a report of the edited/approved time should be reviewed shortly after the payroll cycle.	Management Update - Oct 2019 In progress. To be completed by the end of 2019.

3.4 CUSTOMER SERVICE & COMMUNICATIONS PROCESSES (COMPLETED IN Q1 2019)

a) Hydro Ottawa's decision to place the customer at the heart of its strategy, plans and operations is reflected in rising levels of satisfaction among Hydro Ottawa's customers.

b) The challenge now is to reflect those achievements appropriately in regulatory submissions to the OEB.

c) Action is needed, and swiftly, to address risks and exposures in the protection and management of privacy and customers' personal information. Immediate priorities may include: retention of information; role-appropriate access to information; limiting the needless increase of 'attack surfaces'; enforceable contractual protections with vendors; incorporating security features on laptops.

Table K – Internal Audit of Customer Service and Communications Processes - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should formalize and strengthen its governance model and practices around customer experience projects and initiatives.	Management Update - Feb 2020 In progress - The Customer Experience Steering Committee is revisiting its governance model and practices. Target implementation date: Q1 2020
#2 Given the relatively tight timelines we would urge management to consider the development of a customer-centred narrative for the 2021-2025 rate application a priority. One option to consider, in this context, would be to ensure that the Chief Customer Officer takes the lead in compiling and analyzing the metrics, benchmarking information and comparator information required for the 2021-2025 rate application, for all customer touch-points across the LDC, including those where the CCO Division is not the point of contact or the channel for service delivery. That would allow Hydro Ottawa to highlight qualitative and tangible benefits accruing to the customer, craft a powerful narrative, and comply with the OEB's requirements.	Implemented
#3 We recommend that management should take the following immediate steps to limit the use, disclosure and retention of personal customer information as well as strengthen safeguards. Vendors: 1. Put in place contractual agreements with vendors who share or have access to customers' personal information. The control and protection mechanisms in each case should be devised on the basis of the sets of information that may be "at risk." Existing contracts should be reviewed and revised to ensure consistency of protection across each risk category. 2. Establish a process for periodic on site review of vendors' practices, to ensure compliance with contractual commitments. Retention of Personal Customer Data and Safeguards:	Management Update - Feb 2020 In progress - "At risk" data now protected by contractual agreements. Contractual compliance review program & frequency of review being defined. Deletion of unnecessary personal customer information from all CIS environments complete except for pre-2004 database. Review of personal customer information to occur semi annually. Yearly CIS user access review to be extended to non-production environments. Disk encryption of laptops nearing completion. Target implementation date: Q4 2020

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
3. Update interface diagrams to include all interfaces (manual & automated); identify the data classification and establish a process to keep documentation up to date. 4. Delete any personal customer information (e.g., SIN; birth certificate numbers; mother's maiden names; etc.) which are no longer required for business purposes or processes. The purge of data should extend to all formats and archives. 5. Establish a process to vet and authorize information sets that must be replicated in every CC&B environment, with a view to containing needless exposure. 6. Establish a periodic review process for users of the CC&B application, in order to verify that access to personal customer information is appropriately restricted on a 'least privilege' and 'need to know' basis. 7. Periodically review access to directories on shared network drives where personal customer data is stored (due to interfaces or reports) and limit access to the minimum required to complete business processes. 8. Incorporate security protections on Company-issued laptops to mitigate the risks that might arise if a laptop is stolen or misplaced.	
#4 As part of the corporate privacy protection framework that is planned to be developed, management should consider: 1. Refreshing the privacy policy on HydroOttawa.com to reflect changes to existing privacy legislation or new requirements from the OEB. 2. Developing user guides, FAQs and training material that would allow a consistently applicable definition of personal information, as relevant to Hydro Ottawa's lines of business. 3. Integrating training on responsible and secure information of customer information in new employee orientation, along with refresher courses for existing employees. 4. Developing and rolling out enterprise-wide a	Management Update - Feb 2020 In progress - The Privacy Committee has retained PwC to begin the process of documenting the program. Drafts are expected by the end of Q2. Target implementation date: Q4 2020

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
standalone Privacy Breach Incident Response Plan. This should be folded within the corporate emergency response and business continuity management program, with a regular schedule for scenario building and stress testing. 5. Develop a process to confer periodically with frontline management on the privacy implications, if any, of Canadian or international legislation / regulation, e.g. the adoption by the European Union of General Data Protection Regulation (GDPR).	

3.5 METERING OPERATIONS (COMPLETED IN Q1 2019)

a) Management has recognized the long-term financial and technological implications of metering devices and Advanced Metering Infrastructure ("AMI"). The commissioning of a review of options and alternatives from the consulting firm, Black & Veatch, appears to be both prudent and effective.

b) In addition to diversifying options, Black & Veatch's report should also assist in clarifying the path to take, for better utilization of Big metering Data for a variety of purposes across the organization.

c) Management has decided to relinquish its Measurement Canada accreditation as an Authorized Service Provider, and outsource its meter sealing services. Internal Audit believes that decision is prudent and appropriate.

d) The actions taken by management, as well as other steps to improve efficiency and effectiveness, support the conclusion that the issues raised by Internal Audit in the 2015 audit have been addressed substantively, and with purpose.

Table L – Internal Audit of Metering Operations - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Management should formulate a plan to identify and examine alternatives to the existing smart meter vendor. The plan should consider not only the technical features of alternative products and their conformance to Measurement Canada and IESO criteria, but the resilience, performance and flexibility of the related data aggregation system. Particular consideration should be given to making the data aggregation system capable of capturing data from every generation and brand of meter.	Implemented
#2 Management should consider enlarging the role of Metering, to include monitoring of revenue integrity and system performance. The revised mandate could include devising specific, data-driven value propositions for key customers, which would embrace CDM and other services. At the same time, with a view to preparing for distributed generation, the capital budget for Metering should include provision for installation of meters at key distribution points and facilities.	No longer applicable
#3 In the run up to the full implementation of the telecommunications blueprint (just over 3 years), management should devise a plan for a Big Data aggregation system for Metering and related services, including the requisite analytical tools. An important consideration in identifying a solution would be its ability to read, process and compile signals from multiple brands of devices and sources. In addition to examining the suitability of off-the-shelf products, management should also consider the possibility of creating a strategic partnership with a suitably qualified firm, with a view to developing a platform that creates secondary commercial opportunities.	No longer applicable
#4 We recommend that management should review its existing sampling and testing methodologies to take advantage of the flexibility allowed by Measurement Canada. Perhaps a phased transition would be most appropriate. The results of the QA program should be appropriately factored into the smart meter replacement strategy; this would be especially pertinent from the year 2020 onwards.	Implemented

4. 2018 INTERNAL AUDITS

4.1 MANAGEMENT PRACTICES RELATING TO SYSTEM ACCESS & WORK FOR OTHERS

a) There is a need for formal policy guidance in respect of system access and work for others projects, including principles for decision-making and processes for referral to Regulatory Affairs and the Chief Financial Officer.

b) It would be beneficial if a decision-support framework could be developed, backed by a quality assurance process to review accuracy of cost allocation computations. Internal Audit has also recommended that inputs / revisions to the economic evaluation model be done through standardized criteria and processes.

c) The process for 'trueing up' and managing deposits should be transferred to the Chief Financial Officer division, which has the requisite skills and objectivity.

Table M – Internal Audit of System Access & Work for Others - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 Policy guidance for service layouts & system access design projects required for decisions with regulatory and financial implications	Management Update - Feb 2020 In progress - The Conditions of Service Working Group together with Finance is assessing the costing practices for service layouts & system access design projects. Target implementation date: Q2 2021
#2 Formal decision-support and analysis frameworks, backed by systematic quality assurance review required for consistent application of the economic evaluation model	Management Update - Feb 2020 In progress -In order to reduce the risk and increase oversight in this area, the CFO and CEDO will commission a System Access Working Group. Target implementation date: Q4, 2020
#3 Management should: i) Transfer the responsibility for managing expansion deposits and “trueing up” with customers to the CFO Division, which has the requisite skill-set and is accountable for financial and regulatory implications. Project Managers may continue to be the interface to the customer. ii) Review the implications of the current stance of waiving the expansion deposit for identified customer classes. iii) Standardize the true-up process.	Management Update - Oct 2019 In progress - Management has reviewed and generally accepts the recommendations put forth by Internal Audit. The true-up process has historically been managed as a joint effort between CEDO and CFO, with load calculations and final determination for release residing with CEDO. CEDO is aligned to reviewing the practices noted above in collaboration with CFO and Regulatory Affairs.
#4 We recommend that management should work with the CITO Division to take the following steps: i) Developing and testing IT disaster recovery plans for key systems (C55, Quadra) in line with their classification ii) Defining an approach for support to C55 and Quadra, taking into account skills sets and cost to company, which would relieve Design and Engineering staff of that responsibility iii) Simplifying the number of manual interfaces and data manipulation required between key systems and automating the interfaces if possible	Management Update - Oct 2019 In progress - Management has reviewed and generally agrees with the recommendations put forth by Internal Audit. CEDO specific IT systems generally lack integrations, disaster recovery plans, strategic planning and support. CEDO is committed to working collaboratively with IT to develop a plan to mitigate the points noted above.

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
iv) Removing generic accounts in G/NetViewer after a detailed review of those who have access to this application, so that access is limited to those who require the application for their work. v) Establishing a periodic review process for users of the G/NetViewer application, in order to verify that access to Hydro Ottawa's distribution network is appropriately restricted on a 'least privilege' and 'need to know' basis	

4.2 PROJECT MANAGEMENT PRACTICES IN THE CHIEF ELECTRICITY DISTRIBUTION OFFICER DIVISION

a) Project management practices within the CEDO division need strengthening. Although project management processes have been implemented, adherence to those processes varies considerably across the project portfolio.

b) Greater rigour in adhering to the established methodology, together with some investment in training, should result in improvements. There may also be some benefit in separating the role of distribution designer/distribution engineer from the role and responsibilities of project manager. Project monitoring and support activities require focus.

Table N – Internal Audit of Project Management Practices in the Chief Electricity Distribution Officer Division - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 We recommend that management take the following actions to strengthen project management practices: 1. Reviewing and updating the project management methodology documentation (Project Coach) to ensure it is pragmatic, reflects desired work practices, and incorporates updated tools. 2. Establishing a process for periodic review of Project Coach to ensure it evolves to incorporate new standards (e.g., ISO 55001) and updated technologies. 3. Training project managers on Project Coach, with periodic refresher courses. 4. Instituting a review process to confirm that the requisite project artifacts are created, at least for projects of 'medium' or 'high' complexity. 5. Examining if there are benefits to separating the role of distribution designer/distribution engineer from the role and responsibilities of project manager, with a view to better utilizing the skills and aptitudes of all staff.	Management Update - Feb 2020 In progress - Gaps within CEDOs PM framework, to be identified with assistance of consultant. A recommended path forward for mitigation and improvement to be defined. Target implementation date: Q2 2020
#2 Construction project budgeting and financial monitoring mechanisms need strengthening and decision frameworks should include Finance and Regulatory Affairs, as required.	Management Update - Feb 2020 In progress - Management continues to improve oversight of capital spending, including the accuracy of estimates and change request mechanisms. Target implementation date: Q2 2021

4.3 INFORMATION MANAGEMENT AND INFORMATION SECURITY (COMPLETED IN Q1 2020)

a) The foundations of the Information Management ("IM") program need to be strengthened. A particular focus is required around completing the taxonomy for classification of information assets, for sensitivity and for criticality.

b) The records or information assets which could be considered 'vital' to Hydro Ottawa have not been systematically identified. In the circumstances, there cannot be the requisite assurance that Hydro Ottawa's control frameworks for information management, information security, and privacy protection are designed soundly, and functioning effectively.

c) Internal Audit has recommended the creation of a single governance structure for the IM program, as also related programs such as Cybersecurity and Privacy Management. That should provide Executive management an integrated view on how these key risks are being managed.

d) Hydro Ottawa now has a process to assess Privacy Impact, as part of every information technology project. Establishing an escalation and approval procedure as part of this process would ensure that Executive management gets appropriate line of sight on residual risk, where applicable.

Table O – Internal Audit of Information Management and Information Security - Recommendations and Action Taken

Synopsis of Recommendation	Overview of Action Taken
#1 With a view to strengthening the foundations of the IM program, management should complete the following steps, as a priority: • Finalize separate sensitivity (public / internal only / confidential) and criticality (vital record: yes / no) classifications, decoupling sensitivity from criticality of information, ensuring the definition of confidential encompasses private and personally identifiable information of employees and customers. • Roll-out the new Information Classification Scheme and Retention Schedule (ICSRS) These steps need to be executed independent of the rollout of the new electronic document and records management system (EDRMS) AODocs/G Suite. Arguably, severing the link between EDRMS and the IM program may better serve both initiatives.	Management Update - Mar 2020 In progress - Management agrees and is formulating an action plan to address the items identified.
#2 Management should identify, classify and protect its "crown jewels" as a priority. We believe a deadline-bound exercise (3 months?) led by the Executive Management Team may be more successful than an approach built upwards from Supervisor / Manager level. In parallel, management should pursue the rapid rollout of agreed criteria for classification of information assets for criticality and sensitivity. In respect of structured information assets (e.g., databases) we would recommend using the "high water mark" concept. (Example: if a database stores banking information for a customer, then, according to the classification definitions, the entire database should be classified as confidential.) In the case of unstructured information assets, it would be useful to assign specific responsibility to the manager of each section, requiring them to add the classifications to their folder and subfolder structure.	Management Update - Mar 2020 In progress - Management agrees and is formulating an action plan to address the items identified.
#3 Management should consider striking a joint Information Management & Information Security (including Privacy and Cybersecurity) Committee, co-chaired by the Chief Information & Technology Officer and the General Counsel. The new joint committee would oversee the Information Management program as well as the development of the necessary safeguards for privacy and cybersecurity.	Management Update - Mar 2020 In Progress - Management agrees and is formulating an action plan to address the items identified.

Synopsis of Recommendation (CONT'D)	Overview of Action Taken (CONT'D)
Its mandate would include: prioritizing objectives for Information Management & Information Security; developing a road map, outlining interrelated objectives / dependencies and timelines; publishing essential policies, procedures and work instructions; setting the terms of engagement with the rest of the organization. Such a 'lean' leadership and governance model could over a period of time ensure that Hydro Ottawa's practices for the management and protection of information become a culture that is as rigorous and reliable as it is in the case of, for example, workplace safety.	
#4 Management should determine the minimum information management and information security (which includes cybersecurity and privacy) requirements which must be met by any IT application or technology implemented within Hydro Ottawa. An evaluation of the IT application against these requirements should be conducted as part of the IT intake process. Management should then define what circumstances, if any, would warrant an exemption to these requirements. In the event that requirements are waived, the information security risk exposure and related compensating controls to be implemented should be clearly documented. It would be advisable to establish authority levels for exemption requests and approvals. Internal Audit recommends that the CITO, General Counsel and the Executive accountable for the information stored with the IT application review and approve all waivers.	Management Update - Mar 2020 In Progress -Management agrees and is formulating an action plan to address the items identified.

4.4 EMERGENCY RESPONSE & BUSINESS CONTINUITY MANAGEMENT - FOLLOW-UP (COMPLETED IN Q1 2020)

a) There were four recommendations outstanding from the March 2018 Internal Audit review of Emergency response and Business Continuity Management.

b) Management has implemented a recommendation to complete the business impact assessments for all mission-critical processes.

c) Management has made considerable progress in implementing a recommendation relating to the strengthening of emergency response and business continuity exercises. By Q4 of 2020, management expects to complete action on: (i) developing an exercise

design guide for plan owners, together with training; and, (ii) complementing fire / building evacuation drills with exercises incorporating identified threat scenarios.

d) In response to a recommendation regarding the development of scenarios and responses for emergency situations that may not touch upon electricity generation or distribution, management has completed an exercise framework which includes a number of non-electrical scenarios. Plans for drills and rehearsals are expected to be completed by Q4 of 2020.

INTERROGATORY RESPONSE - SEC-32

1-SEC-32

EXHIBIT REFERENCE:

[Ex-2015-0004, Hydro Ottawa Response to CCC IR #41]

SUBJECT AREA: Productivity

Hydro Ottawa stated: "Currently Hydro Ottawa is working to develop Performance Matrices that will improve and enhance benchmarking, business plan development and accomplishment reporting processes by tracking effectiveness and efficiency of the investments made. The project will be completed in 2015. This will allow 2016 data to create a baseline to be compared to that of 2017 and on." Please provide a copy of the reference matrices that were developed in 2015, the 2016 baseline data, and comparison data for 2017 to 2019.

RESPONSE:

Hydro Ottawa confirms that the performance matrix development project referenced in the interrogatory was completed in early 2016. However, the original implementation plan was ultimately modified for a few reasons. One reason was that the project consultant retained by Hydro Ottawa ended up proposing an unexpectedly high number of performance metrics for the utility's adoption, many of which were also more granular than anticipated. In addition, the timeframe in which the utility was assessing the optimal path forward for adopting and monitoring the metrics happened to coincide with the initiation of preliminary internal discussions regarding the potential value of implementing, or even pursuing certification of, the ISO55000 standard for asset management systems.

In due course, a decision was made at the senior management level to adopt the ISO55000 Asset Management Standard and seek applicable certification.[1] In turn, the outcomes from the

[1] As described in Attachment 2-4-3(J): ISO 55000 Gap Analysis, this ISO standard represents an internationally recognized best-in-class standard for asset management systems.

performance matrix project were migrated over and integrated into the process for seeking ISO55000 certification. More specifically, they have informed the development of a formal procedure to describe Hydro Ottawa's method for monitoring the performance of its Asset Management System ("AMS") in relation to the objectives outlined in the utility's "Strategic Asset Management Plan."[2] This procedure, enshrined as the "Asset Management System Continual Improvement Plan," employs a range of Key Performance Indicators ("KPIs") for monitoring and continually improving the utility's AMS. This procedure also verifies that the utility has established a formalized structure and forum – an Asset Management Council ("AMC") – for the development, review, adoption, modification, and removal of asset management KPIs.

A copy of this procedure is appended to this interrogatory response as Attachment SEC-32(A): IAP0025 - AMS Continual Improvement Plan. Please see page 7 of the document for a table identifying all of the continual improvement KPIs employed by Hydro Ottawa.

In addition, a spreadsheet displaying Hydro Ottawa's dashboard tool for tracking the AMS KPIs is appended as Attachment SEC-32(B): KPI Dashboard.

[2] A copy of the Strategic Asset Management Plan is included in this Application as Attachment 2-4-3(G).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0025**	REV: **1**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-21		

Asset Management System

Continual Improvement Plan

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-01-14	sh/gp/jm
1	Updated Appendix A & B to align with annual review	2020-02-21	ad/lh

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1. Introduction

This procedure describes the process used for continual improvement of Asset Management and the Asset Management System (AMS) at Hydro Ottawa.

The purpose of this procedure is to describe the method used at Hydro Ottawa to monitor the performance of the AMS with respect to the Asset Management Objectives described in IAP0003 *Strategic Asset Management Plan*. This document additionally describes how preventative actions, steps to address non-conformance and steps for corrective actions are recorded and executed, while discussing how any opportunities to improve the AMS are implemented. Hydro Ottawa's involvements with external bodies (namely third party working groups) are further described which allow for new asset management related technologies and practices to be learned and incorporated as deemed necessary.

2. References

British Standards Institution − ISO55001
Hydro Ottawa − POL-ED-IAS0001-01 – Asset Management Policy
Hydro Ottawa − IAS0002 − Asset Management System Manual
Hydro Ottawa − IAS0003 − Strategic Asset Management Plan
Hydro Ottawa − IAP0022 − Asset Management System Risk Procedure
Hydro Ottawa − Enterprise Risk Management Charter
Hydro Ottawa − PRO-MS-001 – OHSE Risk Management (Environmental Aspects and Safety Hazards)

3. Scope

This procedure applies to the monitoring and implementation of continual improvement of Hydro Ottawa's AMS and system level Asset Management activities involving distribution and station assets (further referred to as distribution assets). This procedure does not apply to the performance and continual improvement of individual asset classes, which are addressed in Hydro Ottawa's *Asset Management Plans,* IAP0001 – IAP0013.

4. Continual Improvement Process

4.1 Key Performance Indicators (KPIs)

Asset Management and the AMS at Hydro Ottawa are monitored via Key Performance Indicators (KPIs). Approved KPIs, their definition, and the section responsible for providing measurement are identified in Appendix A

KPIs are developed by the Asset Management Council (AMC) and measurements are recorded annually. KPIs are reviewed at quarterly AMC meetings. In the year of the meeting, KPIs are aggregated and annualized to the quarter of the year in question. This means that KPIs for the year in question are calculated up to the date in question. KPIs presented at the AMC with the understanding that the KPI may not be able to be compared with the target, if the KPI in question requires one year of data.

The development of KPIs can originate from any member of the AMC. Furthermore, KPIs may be developed as part of risk mitigation for risk or non-conformances identified as per IAP0022 *Asset Management System Risk Procedure.* KPIs may also be deemed to be ineffective and may be removed from the KPI system.

New KPIs and any modifications to KPIs must be presented at AMC quarterly meetings and reviewed by the AMC. The Asset Manager approves new KPIs and modified KPIs.

Suggestions for KPI removal must be presented at AMC quarterly meetings and reviewed by the AMC. The Asset Manager approves the removal of any KPIs.

The list of KPIs, formal addition of KPIs, and formal subtraction of KPIs occur at year start. Both this document and IAP0025 *Schedule 1 KPI Dashboard* are updated accordingly after any KPI changes.

KPIs can exist as approved metrics, but may not be measureable at the time of approval. For example, if a KPI is created in one year, but it is known that measurement will not begin until the following year, the KPI can be created and be non-reported until measurement data is available.

Furthermore, KPIs may exist and the measurements for obtaining the KPI be known, but the practicality of taking the measurement is unknown. In such a case, the KPIs are recorded as *Under Consideration*, and documented in Appendix B In order to be classified as *Under Consideration*; a KPI must be reviewed by the AMC, approved by the Asset Manager and there must be a plan in place to ensure KPIs will be implemented and measured.

KPIs are recorded and displayed in *Schedule 1 KPI Dashboard* (KPI Dashboard). Any change to the graphical display of the Dashboard does not require approval by the Asset Manager, but the content of information displayed must not change.

4.2 Preventative Action & Opportunities for Improvement

At quarterly AMC meetings, KPI values and trends are presented. It is the responsibility of the AMC to recognize positive, negative, and neutral trending KPIs. From these trends, the AMC must provide recommendations for preventative or reactionary action and any opportunities for improvement.

When preventative action or opportunities for improvement are identified as a result of the continual improvement KPIs, this should be recorded in IAP0022 *Asset Management Risk Procedure Schedule 1 Risk Register*. Appropriate classification, control action and documentation shall occur as described in IAP0022 *Asset Management System Risk Procedure*.

Preventive actions or opportunities for improvement of Asset Management and the AMS at Hydro Ottawa may also be a result of experiential testimony or other sources. In such a case, these items should be recorded as per IAP0022 *Asset Management System Risk Procedure*. Upon presentation at the AMC quarterly meeting, these cases should be evaluated by the AMC for whether or not a KPI should be developed, or an existing KPI be modified.

4.3 Non-Conformance & Corrective Action

Non-conformance of Asset Management and the AMS, and any resulting corrective action can occur when Hydro Ottawa does not meet a KPI for continual improvement, and from gaps in internal and external audits of the AMS relative to ISO 55001. The audit process is described in IAP0024 *Asset Management System Audit Plan*. Any non-conformance items shall be communicated as per IAP0021 *Asset Management System Communication Plan* and IAP0022 *Asset Management System Risk Procedure.*

Non-conformance should be identified and recorded as a risk as per IAP0022 *Asset Management System Risk Procedure.* Corrective action is the control associated with the prescribed risk. The corrective action, or control, should be tracked and the results of the control recorded to understand how the non-conformance was mitigated and how it can be avoided in future cases.

4.4 Asset Management Working Groups

As described in IAS0003 *Strategic Asset Management Plan*, Hydro Ottawa participates in and supports numerous external and internal councils, committees and working groups. This participation is in and of itself a method for Continual Improvement, as the Asset Management Working Groups allow for the collaboration of industry experts on topics pertinent to the business. External groups allow Hydro Ottawa to both learn and teach others on the best practices in the industry and to understand where trends and changes are coming. A complete list of Asset Management Working Groups is described in IAS0003 *Strategic Asset Management Plan*.

5. Roles & Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities with respect to continual improvement are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3

Business Support: Additional groups and sections responsible for enabling asset management objectives and the success of the AMS.

Appendix A Continual Improvement KPIs

Item	Key Performance Indicator (KPI)	Description	Reporting Period	Section Responsible
	Levels of Service – Customer Engagement			
1	Number of Project Open Houses	As part of the process in implementing a project, Hydro Ottawa holds forums for the public to present projects within communities to address any questions the public may have, and incorporate public opinions into designs. Representatives across the organization involved in different aspects of the project lifecycle from Hydro Ottawa attend to provide awareness of Hydro Ottawa related work in a community and take action on recommendations that come out of these sessions. This metric quantifies the number of said forums as a percentage of the total number of projects.	Quarterly	Communications /Media & Public Affairs
2	Post Work Survey Satisfaction	Upon completion of work in a community, Hydro Ottawa issues a survey to community members to determine satisfaction in various areas as a result of the work.	Quarterly	Customer Engagement
	Levels of Service – Service Quality			
3	SAIDI	System Average Interruption Duration Index (SAIDI).This index is designed to provide information about the average time customers' electrical service is interrupted. SAIDI is computed as: $$SAIDI = \frac{Total\ hours\ of\ customer\ interuptions}{Total\ number\ of\ customers\ served}$$ This index calculation does not include any Loss of Supply outages or outages as a result of Major Event Days. The calculation of this index will include a forecast to the end of the year in question, where a 5 year average will be used on months that have not occurred.	Quarterly	Asset Planning
4	SAIFI	System Average Interruption Frequency (SAIFI). This index is designed to give information about the average frequency of sustained electrical service interruptions per customer. SAIFI is computed as: $$SAIFI = \frac{Total\ number\ of\ customer\ interuptions}{Total\ number\ of\ customers\ served}$$ This index calculation does not include any Loss of Supply outages or outages as a result of Major Event Days. The calculation of this index will include a forecast to the end of the year in question, where a 5 year average will be used on months that have not occurred.	Quarterly	Asset Planning

Item	Key Performance Indicator (KPI)	Description	Reporting Period	Section Responsible
5	$FEMI_n$	Feeders Experiencing Multiple Sustained Interruptions (FEMI). This index represents the number of feeders experiencing sustained (greater and equal to 1 minute) outages greater than or equal to value n; current reporting is done for n=10.	Quarterly	Asset Planning
6	SARFI Prohibited Events (Hydro Ottawa Caused)	System Average RMS Variation Frequency Index (SARFI). SARFI is an indicator of system power quality which measures the average number of voltage sags/swells on the system. This index looks specifically at SARFI events that are caused by Hydro Ottawa or occur on the distribution system (i.e. excluding events originating from the transmissions system or other third parties).	Quarterly	Asset Planning
7	Power Quality Complaints	The number of customer escalations due to power quality issues.	Quarterly	Stations/Service Desk
	Levels of Service – System Accessibility			
8	Stations Exceeding Planning Capacity	The percentage of stations with a peak loading above 100% of the planned capacity rating, where the planned capacity is the rated capacity with the largest supply element at the station is out of service.	Annual	Asset Planning
9	Feeders Exceeding Planning Capacity	The percentage of feeders with a peak operating above 100% of the planned capacity rating, where the planned capacity is determined based on the circuit configuration and cable or wire type.	Annual	Asset Planning
10	Hydro Ottawa Stations Unable to Accept Energy Resource Facilities (ERFs)	The quantity of Hydro Ottawa owned substations that due to equipment limitations cannot accept ERFs. Equipment limitations typically include short circuit limitations and thermal rating capacity.	Annual	Asset Planning
11	Hydro One Networks Inc. (HONI) Stations Unable to Accept ERFs	The quantity of the number of HONI owned stations, to which HOL has downstream connected customers, and are unable to connect ERFs.	Annual	Asset Planning
	Asset Value – Value Optimization			
12	Project Portfolio Value/Budget	The average normalized capital value of projects to the budget of the projects presently planned by Hydro Ottawa. This index is meant to demonstrate the expected value for money obtained from the project portfolio for System Renewal and System Service projects.	Annual	Asset Planning

Item	Key Performance Indicator (KPI)	Description	Reporting Period	Section Responsible
	Asset Value – Asset Lifecycle Cost			
13	3 Year Average Cost per Pole - Wood Pole Replacement	The three-year average cost to relocate a single wood pole (components such as risers and underground cable are excluded)	Annual	Asset Planning
14	3 Year Average Cost per Meter - UG Cable Replacement	The three-year average cost to replace a meter of underground cable (civil duct banks and associated secondary devices are excluded).	Annual	Asset Planning
15	Average Cost per Kilometer - Vegetation Management	The average cost to clear vegetation along one kilometer of distribution line.	Annual	Asset Planning
16	Average Cost per Pole - Pole Test and Inspection	The average cost to test and inspect a single pole.	Annual	Asset Planning
17	Inventory Turnover Ratio	The ratio of the cost of materials used to the average cost of inventory.	Quarterly	Procurement
18	Percentage of Assets in Various Condition	The percentage of assets that are in “Very Poor” condition as defined by the Asset Condition Assessments.	Annual	Asset Planning
19	Asset Record Accuracy	Percentage of accurate GIS asset data compared to actual assets in the field reported via maintenance programs.	Annual	Maintenance and Reliability
	Resource Efficiency – Employee Competency			
20	AMS Awareness Survey	The number of employees responses who are aware of Hydro Ottawa’s AMS based on an annual survey.	Quarterly	Asset Planning
	Resource Efficiency – Productivity Management			
21	Productive Time	Productive time represents the total regular hours charged to a work order (billable) as a ratio to total regular hours. The target of the productive time KPI is to maximize this index by identifying and improving efficiencies.	Quarterly	Finance
	Resource Efficiency – Resource Optimization			
22	Labour hours / cost of material installed	The total number of hours spent on labour by Hydro Ottawa crews, divided by the cost of the material that was installed. This index creates a relation between hours worked and material spending.	Quarterly	Program Management
23	Material Returns – Aggregate Value ($’000,000)	The amount of material returns from all asset classes in the millions.	Annual	Supply Chain

Item	Key Performance Indicator (KPI)	Description	Reporting Period	Section Responsible
	Health, Safety & Environment - Employee & Public Safety			
24	Quantity of Public Safety Concerns	Public safety concerns are documented and quantified for this index (count per year).	Quarterly	OHSE
	Health, Safety & Environment - Environmental Stewardship			
25	Annual Number of leaking transformers	The total annual number of leaking transformers	Quarterly	OHSE
26	Annual Oil Clean Up ($'000)	The annual cost of oil remediation.	Quarterly	OHSE
	Compliance – Internal Compliance			
27	Number of Gaps Identified - Internal Audits	As part of the AMS at Hydro Ottawa, Internal Audits are performed and the gaps between the AMS and the ISO 55001 standard are identified. This index quantifies the number of major non-conformance gaps identified by an internal auditor.	Quarterly	Asset Planning
28	Technical Documents past re-affirmation date	As part of DFS0007, technical standards at Hydro Ottawa shall be updated or re-affirmed after 7 years. This index quantifies the number of standards past re-affirmation.	Quarterly	Standards
29	Capital Projects Completed / Number of Capital Projects	The progress of capital projects is measured annually, by recording the number of completed projects in a particular year relative to the number of planned project completions, namely System Service and System Renewal, projects. This metric is measured as a percentage of projects planned for completion, excluding carry overs and multi-year projects not expected to be energized in the current year.	Annual	Asset Planning
30	Maintenance Completed / Number of Planned Maintenance Activities	The progress of the maintenance programs at Hydro Ottawa is measured annually by relating the number of complete maintenance programs to the total number of maintenance programs, non-inclusive of corrective actions.	Annual	Asset Planning
	Compliance – External Compliance			
31	Number of Gaps Identified - ISO 55001 Audit	As part of the AMS at Hydro Ottawa, External Audits are performed and the gaps between the AMS and the ISO 55001 standard are identified. This index quantifies the number major non-conformance gaps.	Quarterly	Asset Planning
32	Did we comply with 22/04 Audit	Hydro Ottawa's annual compliance against Ontario Regulation 22/04.	Annual	Standards
33	Budget Compliance (Cost Efficiency)	Cost Efficiency is a KPI of the amount of planned capital activities as a ratio to actual capital activities performed throughout the year. Cost efficiency is strictly a measure of all planned projects in System Renewal and System Service Investment Categories, but does not include System Access or General Plant investments	Quarterly	Finance

Item	Key Performance Indicator (KPI)	Description	Reporting Period	Section Responsible
34	Capitalization Efficiency	Capitalization Efficiency is a KPI of the amount of planned capitalization activities as a ratio to actual capitalization activities performed throughout the year. Capitalization efficiency is strictly a measure of all planned projects in System Renewal and System Service Investment Categories, but does not include System Access or General Plant investments	Quarterly	Finance
35	Capital Planned OT Hours vs Total Hours	The percentage of Planned Overtime Hours on capital projects as a percentage of total hours. Measures only System Service and System Renewal projects.	Annual	Asset Planning

Appendix B Continual Improvement KPIs Under Consideration

Item	Key Performance Indicator (KPI)	Description	Section Responsible
Levels of Service – Service Quality			
1	Customers Experiencing Long Duration Interruptions (CELDI)	Customers Experiencing Long Duration Interruptions (CELDI). This index measures the number of customers having experienced outages longer than a predefined duration. The duration for this KPI is under consideration.	Asset Planning
2	Customers Experiencing Multiple Interruptions ($CEMI_{n)}$	Customers Experiencing Multiple Interruptions (CEMI). This index represents the number of customers experiencing sustained (greater than 1 minute) outages greater than or equal to value n; future reporting to be completed for n=10. The measurement tracking of this KPI is under consideration.	Asset Planning
3	Worst Feeder Analysis – Number of Feeders with Very Poor Performance	The number of feeders whose performance is determined to be very poor as assessed from the worst performing feeder analysis.	Asset Planning
4	Value for Money (SIMUL)	Overall customer satisfaction regarding Hydro Ottawa's Value for Money captured via the SIMUL survey.	Customer Engagement
Asset Value			
Resource Efficiency – Productivity Management			
7	Wrench Time	The amount of time a tradesperson is completing field work net of all the travel, planning, lunch and breaks.	Program Management
Resource Efficiency – Resource Optimization			
8	Construction Issues - Internal	This KPI quantifies the number of non-conformance occurrences that occur during construction. The measurement and quantification of this KPI is under consideration.	Program Management
Health, Safety & Environment			
Compliance			

KPI DASHBOARD

* calculation is not completed

- Meets target by more than 5%
- Within 5% of target
- Does not meet target by more than 5%

⇧ Positive Correlation in KPI
⇔ Performance Staying about the same
⇩ Negative Correlation in KPI

Levels of Service

Customer Engagement

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Projected Number of Project Open Houses	Customer Engagement	8	9	14	0	🔴	⇩
Post Work Survey Satisfaction	Customer Engagement	≥ 1.00		0	0	🔴	⇔

Service Quality

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
SAIDI	Assets	≤ 1	0.94	0.77	0.92	🟢	⇧
SAIFI	Assets	≤ 0.80	0.74	0.75	0.75	🟢	⇩
FEMI	Assets	≤ 10	9.40	10	11	🔴	⇩
SARFI Prohibited Events (HOL Caused)	Assets	≤ 6	6.25	10	-	🔴	⇩
Power Quality Complaints	Stations	≤ 10	21.2	2	9	🟢	⇧

System Accessibility

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Stations Exceeding Planning Capacity	Assets	≤ 5%	11%	8.8%	-	🔴	⇧
Feeders Exceeding Planning Capacity	Assets	≤ 10%	2%	1.6%	-	🟢	⇧
HOL stations unable to accept ERFs	Assets	≤ 2	2.33	2	-	🔴	⇧
HOL stations unable to accept ERFs	Assets	≤ 1	1	1	-	🔴	⇧

Asset Value

Value Optimization

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Project Portfolio Value/Budget	Assets		32.95	34.16	-	🔴	⇧

Asset Lifecycle Cost

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
3 Year Average Cost per Pole - Wood Pole Replacement	Assets		$ 7,969.00	$ 7,969.00	-	🟡	⇔
3 Year Average Cost per Meter - UG Cable Replacement	Assets		$ 90.00	$ 90.00	-	🟡	⇔
Average Cost per Kilometer - Vegetation Management	Assets		$ 3,096.00	$ 3,096.00	-	🟡	⇔
Average Cost per Pole - Pole Test and Inspection	Assets		$ 31.00	$ 31.00	-	🟡	⇔
Inventory Turnover Ratio	Procurement	≤ 2	1.77	1.50	1.60	🟢	⇧
Assets in very poor condition	Assets	≤ 5%	12%	12%	-	🔴	⇔
Asset Record Accuracy	Assets	≥ 95%	85%	85.0%	-	🔴	⇔

Resource Efficiency

Employee Competency

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
AMS Awareness Survey	Assets	50	0	0	88	🟢	⇧

Productivity Management

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Productive time	Finance	≥ 75%	73%	72%	73%	🟡	⇧

Resource Optimization

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Labour hours / cost of material installed	Program Management	# 2.50	2.77	2.45	3.54	🔴	⇩
Material Returns - Aggregate Value ($ 000,000)	Procurement	≤ 5.50	$ 5.80	$ 7.10	$ 6.75	🔴	⇩

Health, Safety & Environment

Employee & Public Safety

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Quantity of Public Safety Concerns	OHSE	≤ 2	1.60	2	1	🟢	⇧

Environmental Stewardship

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Annual number of leaking transformer	OHSE	≤ 105	109	100	2	🟢	⇧
Annual Oil Clean Up ($'000)	OHSE	≤ 880	$ 962	$ 950	$ -	🟢	⇧

Compliance

Internal Compliance

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Number of Gaps Identified - Internal Audits	Assets	1		4	0	🟢	⇧
Technical Documents past re-affirmation date	Standards	0	404.5	58	36	🔴	⇧
Capital Projects Completed / Number of Capital Projects	Assets	100%	119%	119%	-	🟢	⇔
Maintenance Completed / Number of Maintenance Activities	Assets	100%	80%	94%	-	🔴	⇧

External Compliance

	Responsible Group	Target	5-YR AVG	2019	2020	Status	Progress
Number of Gaps Identified - ISO 55001 Audit			12.67	6	0	🟢	⇧
Did we comply with 22/04 Audit	OHSE	Yes	Yes	Yes	-	🟢	⇔
Forecasted Budget Compliance (Cost Efficiency)	Finance	100%	86%	86%	89%	🔴	⇩
Budget Compliance (Cost Efficiency)	Finance	100%	96%	84%	15%	🔴	⇩
Capitalization Efficiency	Finance	100%	141%	173%	11%	🔴	⇩
Capital Planned OT Hours vs Total Hours	Assets	≤ 6%	7.2%	5.6%	-	🔴	⇧

INTERROGATORY RESPONSE - SEC-33

1-SEC-33

EXHIBIT REFERENCE:

[Ex.1-2-1]

SUBJECT AREA: Customer Engagement

Question:

On July 11, 2019, Hydro Ottawa held a meeting with customer group stakeholders and OEB Staff, in part, to receive feedback related to its customer engagement plans. Please provide details regarding what changes to its customer engagement plans were made as a result of the feedback obtained from participants of that meeting.

RESPONSE:

On June 11, 2019, Hydro Ottawa and Innovative Research Group Inc. ("Innovative") held a stakeholder workshop with OEB Staff and intervenors. The purpose of this workshop was to present Hydro Ottawa's proposed customer engagement process, share the draft workbook, solicit stakeholder feedback, and answer any outstanding questions related to the engagement process.

To begin the session, Hydro Ottawa provided a brief presentation on the background related to this Application and the utility's customer engagement process. Thereafter, the utility answered questions from OEB staff and intervenors. Following this presentation, Innovative led a group discussion that highlighted the engagement process and walked through the draft engagement instrument (the draft workbook). Innovative encouraged OEB Staff and intervenors to provide their feedback on the content, ask questions, and offer suggestions that might enhance the customer experience.

Following this session, OEB Staff and intervenors were encouraged to submit written feedback to Hydro Ottawa regarding the customer engagement process and any other comments related to the draft engagement materials prepared for the session. Between June 11-17, 2019, no written feedback was received.

Based on the verbal feedback from the workshop, Hydro Ottawa did not make any substantive changes to its customer engagement plans or approach. However, Hydro Ottawa did make both substantive and minor changes to the draft customer engagement workbook. Those substantive changes included the following:

1. **Increasing the number of expenditure options**: It was suggested that, where possible, Hydro Ottawa provide more than three options for investment scenario questions. In response to this feedback, Hydro Ottawa increased the number of investment options from three to four for the following sections of the customer engagement workbook: *"Pacing investments in the underground distribution system*", and "*Reliability investments*." Hydro Ottawa also increased the number of response options for *"Vehicle Replacement"* from two to three.

2. **Reducing the amount of content**: Stakeholders felt that the draft workbook provided too much content that could disincentivize customer participation. In response, Hydro Ottawa and Innovative worked diligently to compress and reduce the overall amount of content presented to customers. Specifically, with regards to capital investment options, topics were reduced from 12 (in the draft workbook) to 9 (in the final workbook).

3. **Providing historical context for capital investments**: In response to feedback, the final customer engagement workbook included historical and forecasted capital budgets by year, as well as cost drivers and trends between 2016-2020 as well as 2021-2025.

INTERROGATORY RESPONSE - SEC-34

2-SEC-34

EXHIBIT REFERENCE:

[Ex.2-4-3]

SUBJECT AREA: Distribution System Plan

Please update the following tables and figures to include 2019 actuals:

a) Reliability Tables: 4.4, 4.5, 4.6, 4.23 (*Note*: Please also provide the updated version of Table 4.23 in excel)

b) Reliability Figures: 4.1, 4.2, 4.3

c) Productivity Tables: 4.9, 4.10

d) Asset Performance Tables: 4.11, 4.13

e) Unit Cost Tables: 4.22

RESPONSE:

a) Please see the response to interrogatory CCC-38 for Tables 4.4, 4.5, and 4.6

For Table 4.23, see Attachment SEC-34(A): Reliability Performance by Cause Code.

b) Please see the response to interrogatory OEB-75 for the updated Table 4.1. See Figure A below for SAIDI Reliability Performance and Figure B below for CAIDI Reliability Performance.

Figure A – SAIDI Reliability Performance

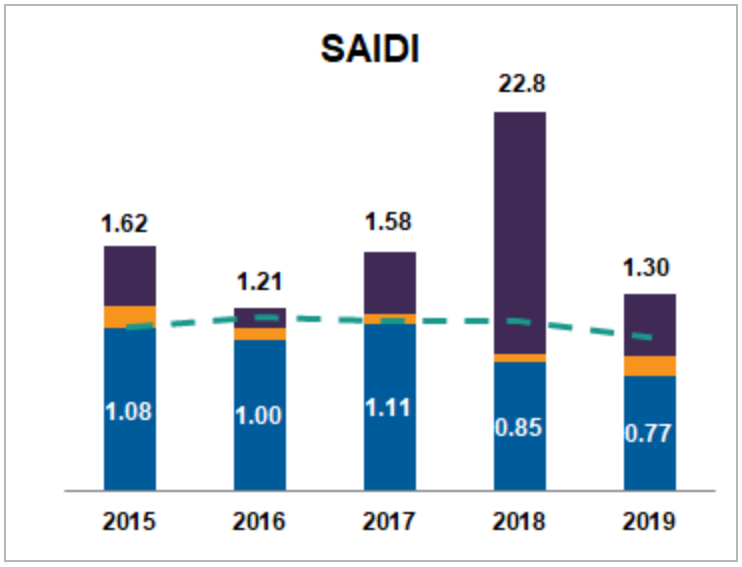
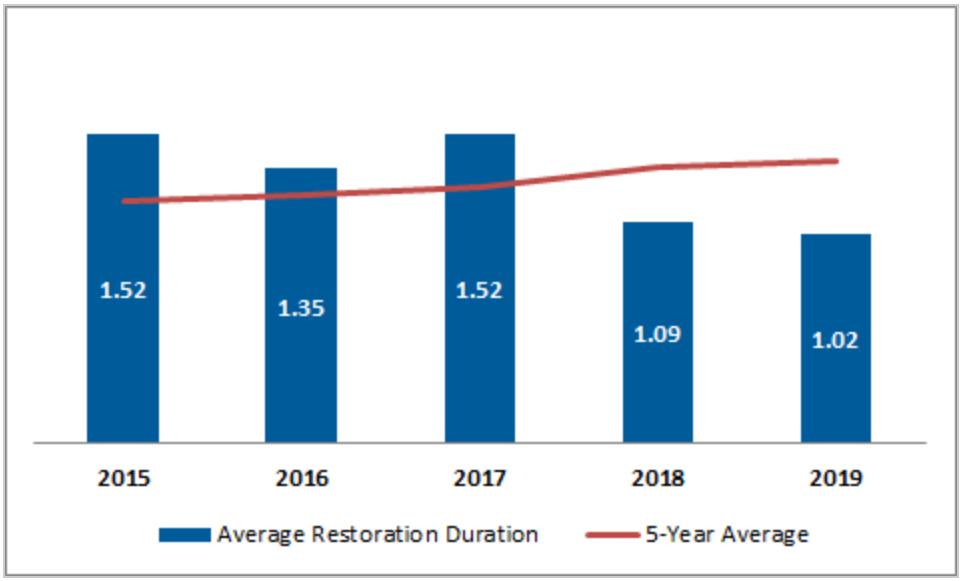


Figure B – CAIDI Reliability Performance



c) Please see Tables A and B for updates to Tables 4.9 and 4.10.

Table A – Productive Time

KPI	Target	2015	2016	2017	2018	2019
ProductiveTime	74%	74%	74%	73%	72%	72%

Table B – Labour Allocation

KPI	Target	2015	2016	2017	2018	2019
Labour Allocation	61%	61%	62%	60%	58%	58%

d) Please see Tables C and D for updates to Tables 4.11 and 4.13.

Table C – Defective Equipment SAIFI per 100 Customers

Asset – SAIFI x 100	Target	2014	2015	2016	2017	2018	2019
Overhead System Assets	10.13	12.73	7.89	6.70	13.69	9.58	5.32
Station System Assets	1.77	0.33	2.28	1.88	0.20	3.65	0.35
Underground System Assets	11.17	13.28	14.89	9.26	5.09	13.26	13.50

Table D – Annual Oil Spills

KPI	Target	2014	2015	2016	2017	2018	2019
Oil Spilled (litres)	0	958	1,133	824	1,119	1,475	1,131*
Oil Remediation ($'000s)	$0	$695	$609	$799	$733	$1,083	$948*

*Not all spills occurring in 2019 have been closed out and invoiced.

e) Please see Table E below for an update to Table 4.22.

Table E – Unit Metric (as per Appendix 5-A)

Metric Category	Metric	1-Year Cost (2019)	5-Year Average (2015-2019)
Cost	Total Cost per Customer	$659	$677
	Total Cost per km of Line	$38,349	$39,396
	Total Cost per MW	$171,374	$163,335
CAPEX	Total CAPEX per Customer	$414	$427
	Total CAPEX per km of Line	$24,106	$24,823
O&M	Total O&M per Customer	$245	$250
	Total O&M per km of Line	$14,243	$14,573

INTERROGATORY RESPONSE - SEC-35

2-SEC-35

EXHIBIT REFERENCE:

[Ex. 2-4-3]

SUBJECT AREA: Distribution System Plan

Question:

For each year between 2016 and 2025, please provide the total value of capital work completed by external contractors.

RESPONSE:

Table A provides the total value of capital work completed or budgeted to be completed by external contractors for the 2016-2025 period.

Table A – 2016-2025 Capital Work Completed/Budgeted for Completion by External Contractors ($'000,000s)

Investment Category	Historical/Budget					Test				
	2016 Actual	2017 Actual	2018 Actual	2019 Actual	2020 Budget	2021 Budget	2022 Budget	2023 Budget	2024 Budget	2025 Budget
System Access	$11.74	$8.33	$16.92	$16.16	$18.71	$19.65	$13.57	$11.08	$9.06	$8.20
System Renewal	$18.78	$20.72	$29.81	$12.67	$14.88	$20.20	$20.62	$18.19	$17.02	$16.43
System Service	$7.72	$11.93	$16.36	$13.75	$12.58	$11.15	$10.93	$9.99	$9.52	$9.18
TOTAL	**$38.24**	**$40.98**	**$63.10**	**$42.58**	**$46.17**	**$51.00**	**$45.11**	**$39.26**	**$35.60**	**$33.81**

INTERROGATORY RESPONSE - SEC-36

2-SEC-36

EXHIBIT REFERENCE:

EB-2016-0004, Ex. B, Attachment 1(A)

SUBJECT AREA: Distribution System Plan

In Hydro Ottawa's 2016-2020 Custom IR application it filed as part of its DSP information for each of its material capital programs for 2016. Please provide a table that shows for each project

a) the forecast cost of the project included in that application,

b) the actual cost of the project,

c) forecast in-service date of the project include in that application,

d) actual in-service date,

e) and variance explanation for costs above +/-10%, and delays of greater than 6 months.

RESPONSE:

Please note that Hydro Ottawa's 2016-2020 Custom IR application was assigned the OEB file number EB-2015-0004.

Excel Attachment SEC-36(A): 2016-2020 Budget vs. Actuals Project Level summarizes the total forecast to actual variance in 2016-2020 and the in-service dates (forecast and actual) for each

project included in EB-2015-0004 as Attachment B-1(A): Material Investments, along with variance explanations for costs +/- 10% and delays of greater than six months.

Please note the following:

- Projects with an in-service date of 2015 completed on-time were excluded.
- Many projects in the Material Investment Plan for 2016-2020 did not have a month in-service date. There is a mix of month, quarter, and year in-service dates in the "Planned In-Service date" column.
- Estimates for projects included in the 2016-2020 Material Investment Plan were preliminary (Level A), meaning that they carry a potential variation of +100%/-50%.

INTERROGATORY RESPONSE - SEC-37

2-SEC-37

EXHIBIT REFERENCE:

None

SUBJECT AREA: Distribution System Plan

Please provide a similar table as requested in 2-SEC-36 that reflects material capital projects for each year between 2017 and 2019, but use internal cost and schedule forecasts as the information does not appear to have been provided in the 2016-2020 Custom IR Application. In your response, please explain the basis of the internal cost/schedule forecast (i.e. at what point in the planning process is it based on etc).

RESPONSE:

Please refer to the response to interrogatory SEC-36 for the Material Investments included in the 2016 Distribution System Plan. Attachment SEC-36(A): 2016-2020 Budget vs Actual - Project Level addresses all projects and all years (2016-2020) in the Material Investments, regardless of the year in which the project occurred.

With respect to internal cost and schedule forecasts, Hydro Ottawa only prepares one Material Investment forecast. However, as noted throughout the variance explanations in Attachment SEC-36(A), some of these forecasts were based on “Level A” estimates versus “Level D” estimates, as described in section 5.2 of Exhibit 2-4-3: Distribution System Plan.

INTERROGATORY RESPONSE - SEC-38

2-SEC-38

EXHIBIT REFERENCE:

Ex.2-4-3, p.97-99

SUBJECT AREA: Distribution System Plan

With respect to the ACA framework:

a) Please provide the mathematical formulation used to create the asset, Health Index.

b) Please explain what data inputs are considered and how they are used in the formula.

c) Please describe any changes made to the ACA framework since its last application.

d) Does Hydro Ottawa track data availability in the database used to develop asset Health Indices? If so, please provide the data availability score (or similar metric).

e) With respect to the asset specific Health Index information provided in the evidence, what was the date the information is reflective of?

RESPONSE:

a) The Health Index is calculated as follows:

$$HI = \left(\frac{\sum_{i=1} Weight_i * Numerical\ Grade_i}{Total\ Score}\right) x\ 100$$

- *i* corresponds to the number of criteria being considered
- Weight is the relative weighting used for each criteria in the calculation
- Numerical Grade is the score assigned (0-4) for each condition

- Total Score is the maximum possible score across all criteria
- Health index ("HI") is the calculated percentage representing the health of the asset

b) The data inputs vary by asset class but include a combination of test and visual inspection data. A weighting is assigned to each criterion to indicate the amount of influence the condition has on the overall health. Each criterion is assigned a score (range 0-4) based on historical data.

c) 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 a summary of the utility's ACA framework and subsequent changes reviewed by METSCO.

d) Where the criteria score is not available due to data gaps, the specific criteria is ignored in the overall health index calculation. A health index can be calculated and is considered valid when data leading to 70% of the total health index score is available.

e) The Health Index information and formulations provided in the evidence were effective as of November 1, 2019.

INTERROGATORY RESPONSE - SEC-39

2-SEC-39

EXHIBIT REFERENCE:

Ex.2-4-3, p.121-122

SUBJECT AREA: Distribution System Plan

Please explain how Hydro Ottawa has determined the cost of customer interruption. Please provide copies of any studies or analyses that were considered in the determination.

RESPONSE:

The cost of a customer interruption was completed in 2015 by a consultant retained by Hydro Ottawa (Metsco), using a Canadian adaptation to the publicly available ICE calculator.[1] This adaptation was reproduced by the Centre for Energy Advancement through Technological Innovation ("CEATI"), using Canadian economic factors. Hydro Ottawa provided inputs of customer data such as number of customers within each class (residential, small commercial and industrial, and large commercial and industrial), percent mix of industry types, current reliability statistics, and residential customer demographics.

The resulting output of the analysis was as follows:

- Residential Event Cost per kVa: $7.81
- Residential Duration Cost per kVA-hour: $1.09
- Small C&I Event Cost per kVA: $158.06
- Small C&I Event Cost per kVA-hour: $146.31
- Small C&I Event Cost per kVA: $17.27
- Large & Medium C&I Duration Cost per kVA-hour: $13.70

[1] Information related to this model and its methodology is available at the following website: https://icecalculator.com/home.

To summarize the cost of an interruption and the duration, Hydro Ottawa uses the following averages in its Project Evaluation:

- Event Cost per kVA: $22.49
- Duration Cost per kVA-hour: $18.08

INTERROGATORY RESPONSE - SEC-40

2-SEC-40

EXHIBIT REFERENCE:

[Ex.2-4-3]

SUBJECT AREA: Distribution System Plan

Please explain how the Hydro Ottawa capital planning process in this application differs from that set out in its last application.

RESPONSE:

Differences between the capital planning process utilized by Hydro Ottawa for the purposes of this Application, relative to the previous application, are as follows:

- A $95.0M cap on Capital Expenditures was established through an asset needs and rationalization process that is described in part (a) of the response to interrogatory OEB-3. The budget and business planning process, including the capital expenditure cap level, is explained in Attachment 1-1-9(A): Corporate Memorandum - 2020-2025 Priorities and Budget Guidelines. The result is a 2021-2025 average annual expenditure of **$94.8M**, excluding the Cambrian MTS project, which is in alignment with historical levels. Please refer to section 3 of Exhibit 2-4-3: Distribution System Plan for more details.
- Copperleaf's Asset Management software, C55, was incorporated into the capital expenditure process. The C55 program allows Hydro Ottawa to automate the optimization process, thereby further improving the ability to mitigate risks and increase benefits amongst a variety of project ideas. Each project alternative is valued based on the utility's corporate strategic objectives. C55 then selects the combination of projects that carry the highest overall value while fitting within specified financial constraints. Please see section 5.2.2 of Exhibit 2-4-3: Distribution System Plan for details.

Table A outlines the phases of the capital expenditure process, adjusted to align with the introduction of C55.

Table A – Capital Expenditure Process and Phases

Capital Expenditure Process (2021-2025 Custom IR)	Capital Expenditure Process (2016-2020 Custom IR)
Project Concept Definition	Project Concept Definition
Project Evaluation	Project Evaluation
Project Review	Project Prioritization
Project Optimization	Project Execution
Project Execution	Risk Assessment & Review

INTERROGATORY RESPONSE - SEC-41

2-SEC-41

EXHIBIT REFERENCE:

Ex.2-4-3, p.121-129

SUBJECT AREA: Distribution System Plan

Please provide a copy of any internal guide(s) used for capital planning.

RESPONSE:

Please see the attachments filed as part of the response to interrogatory SEC-58.

INTERROGATORY RESPONSE - SEC-42

2-SEC-42

EXHIBIT REFERENCE:

Ex.2-4-3, p.129

SUBJECT AREA: Distribution System Plan

Please provide a copy of each of the: a) 'Preliminary Project List', b) 'Detailed Project List', and c) any final project list. Please ensure the lists include all of the value measure calculations.

RESPONSE:

As this process is executed on an annual basis and historical data is not readily available, the data requested has been provided for the 2019 fiscal year only.

Please see the following materials appended to this response:

- Attachment SEC-42(A): 2019 Preliminary Project List
- Attachment SEC-42(B): 2019 Detailed Project List
- Attachment SEC-42(C): 2019 Board Approved Project List

***Project values provided are based on present-day forecasts, as Hydro Ottawa does not maintain records for historical project values.**
****Projects without values have business cases outside of C55 value framework or are placeholders for future work with unknown value (eg. Distribution Plant Failure)**

		2019 Opening Budget	
SR - System Renewal	**$**	**39,809,858**	**Value ($K)**
92099901 - Station Assets Renewal	**$**	**14,681,904**	
92002614 - Station Transformer Renewal	**$**	**1,672,731**	
92008661 - XFRM Repl. Bronson SBT1 & SBT2	$	112,131	22,043
92013592 - Bayswater Transformer Replacement	$	1,560,600	6,596
92003371 - Station Switchgear Renewal	**$**	**3,820,773**	
92010241 - Overbrook Switchgear Replacement	$	3,820,773	20,352
92012234 - Station Major Assets Renewal	**$**	**9,128,000**	
92008485 - Merivale DS Rebuild	$	800,000	63,343
92012741 - Fisher AK Station Rebuild	$	3,490,000	4,005
92013574 - Urbandale AE Station Rebuild	$	1,138,000	1,144
92013576 - Dagmar AC Station Rebuild	$	1,200,000	466
92013596 - Clifton UL Station Rebuild	$	1,000,000	8,283
92013600 - Bell's Corners Station Rebuild	$	1,500,000	16,801
92012236 - Station Minor Assets Renewal	**$**	**60,400**	
92012815 - Kanata MTS - RTU Replacement	$	20,400	152
92013594 - Station Battery Replacement - 2019	$	40,000	929
92099926 - OH Distribution Assets Renewal	**$**	**8,635,765**	
92000021 - Pole Renewal	**$**	**8,335,765**	
92010275 - Britannia Bay Phase 1	$	700,397	2,594
92011896 - Centretown West Pole Repl. 1.4	$	236,730	2,366
92011904 - Centretown West Pole Repl. 1.8	$	1,165,206	5,166
Repl.	$	140,000	2,398
92013580 - Hawthorne/ Whyte Side Rd Pole Repl.	$	80,000	1,122
92013582 - Elmvale Area Pole Repl. Phase 3	$	1,971,000	22,865
92013602 - 2019 Critical Pole Replacement	$	2,000,000	4,096
92013608 - Scott/Winona Pole Repl.	$	500,000	2,049
92013610 - Kirkwood/Hilson Pole Repl.	$	460,000	1,820
92013638 - Edwin Phase 1	$	1,082,432	726
92001860 - OH Switch/Recloser Renewal	**$**	**300,000**	
92013632 - TD01 Porcelain Repl. & Re-Fuse	$	300,000	324
92099958 - UG Distribution Assets Renewal	**$**	**9,369,189**	
92001363 - Civil Renewal	**$**	**520,200**	
92013666 - 2019 Manhole Rehab	$	520,200	-
92001856 - Cable Renewal	**$**	**5,883,290**	
92008609 - Blackburn 4F8 - Phase 4	$	1,587,422	2,607
92012028 - Kakulu Rd Trunk (S51-S62)	$	1,119,574	1,941
92012771 - Glen Cairn Voltage Conversion - Phase 4	$	1,591,812	11,924
92013588 - McCarthy Cable Replacement	$	779,025	-548
92013590 - Cahill Drive Cable Replacement	$	805,457	-770
92001859 - UG Switchgear Renewal	**$**	**861,502**	
92013614 - S642 SG Replacement	$	213,834	1,475
92013616 - S340 SG Replacement	$	213,834	1,364
92013618 - S292 SG Replacement	$	213,834	1,576
92013636 - SC76/SC81 PMH to VISTA	$	220,000	268
92012230 - UG Transformer Renewal	**$**	**604,197**	
92011930 - Malvern XFRM Repl. (Sherway, Tedwyn)	$	396,117	1,075
92013620 - XFRMs on Banner Road	$	208,080	775
92012232 - Cable Rejuvenation	**$**	**1,500,000**	
92012765 - 2019 Cable Injection	$	1,500,000	-
92099959 - Plant Failure	**$**	**5,500,000**	
92002191 - Distribution Plant Failure	**$**	**5,393,000**	
92002191 - Distribution Plant Failure	$	5,393,000	-
92003580 - Station Plant Failure	**$**	**107,000**	
92004361 - Stations Plant Failure	$	107,000	-
92099991 - Metering	**$**	**1,623,000**	
92003564 - Remote Disconnected Smrt Meter	**$**	**1,623,000**	
92003564 - Remote Disconnected Smrt Meter	$	1,623,000	-
SS - System Service	**$**	**28,585,066**	
92099902 - Capacity Upgrades	**$**	**15,597,925**	
92003519 - Stations Capacity Upgrades	**$**	**15,597,925**	
92008537 - New South 28kV Substation Yr 1-7	$	3,714,382	213,716
92008593 - Richmond South DS	$	855,000	338,177
92011956 - Uplands MS Second Transformer (Island)	$	5,163,241	13,603
92012755 - Bridlewood Station Rebuild	$	5,600,000	45,186

92013598 - Riverdale Switchgear Replacement	$	265,302	24,830
92099903 - Stations Enhancements	**$**	**500,000**	
92000044 - Stations Enhancements	**$**	**500,000**	
92001012 - Station Replacement	$	500,000	-
92099927 - Distribution Enhancement	**$**	**6,771,235**	
92001886 - Line Extensions	**$**	**1,323,722**	
92010741 - Shea Re-Stringing	$	1,323,722	26,470
92002622 - System Voltage Conversion	**$**	**3,281,420**	
92010922 - Richmond Voltage Conversion - Perth East	$	979,535	3,355
92010956 - Richmond Voltage Conversion - Fortune	$	605,790	231
92013584 - Stittsville Main (Abbott/Fernbank Tie)	$	851,047	4,772
92013604 - Fringewood Voltage Conversion	$	645,048	276
92013664 - Richmond Voltage Conversion Cut-Overs	$	200,000	2,318
92002626 - Distribution System Reliability	**$**	**1,047,742**	
92009223 - Worst Feeder Betterment 2013-2020	$	150,000	93,144
92011992 - East 44kV Loop Automation	$	367,742	6,226
92013634 - Blackburn BLKF5 Reliability Improvement	$	530,000	-650
92003370 - Distribution Enhancements	**$**	**1,118,351**	
92001781 - CANBAN - Low Value Truck Stock	$	450,000	4,629
92009227 - Level C Design Time	$	200,000	-
92011914 - Motorize Vector Switches	$	143,351	3,023
92013606 - Casselman New Feeder Egress	$	325,000	4,381
92099941 - Grid Technologies	**$**	**5,715,906**	
92000045 - SCADA Upgrades	**$**	**795,906**	
92010422 - SCADA Replacement Project	$	795,906	-
92000046 - RTU Upgrades	**$**	**20,000**	
92005506 - Minor Enhancements Year 1-5	$	20,000	174
92012240 - Communication Infrastructure	**$**	**4,900,000**	
92010414 - Telecommunications Master Plan	$	4,900,000	-
Grand Total	$	68,394,924	995,188

***Project values provided are based on present-day forecasts, as Hydro Ottawa does not maintain records for historical project values.**

****Projects without values have business cases outside of C55 value framework or are placeholders for future work with unknown value (eg. Distribution Plant Failure)**

Scenario: 2019 Detailed Level 'D' Budget List In Dollars

Parent/Program/Project		Budget	Value ($K)
92099901 - Station Assets Renewal		**13,870,724**	
92002614 - Station Transformer Renewal		**1,014,756**	
Central			
92013592	Bayswater Transformer Replacement	588,000	6,596
92011890	Shillington Transformer Replacement	300,000	11,950
92008661	XFRM Repl. Bronson SBT1 & SBT2	126,756	22,043
92003371 - Stations Switchgear Renewal		**3,820,773**	
East			
92010241	Overbrook Switchgear Replacement	3,820,773	20,352
92003405 - Station P&C Renewal		**120,000**	
Central			
92011894	Slater TS relay replacement	120,000	5,249
92012234 - Station Major Assets Renewal		**8,854,795**	
Central			
92013596	Clifton UL Station Rebuild	1,593,724	8,283
92012741	Fisher AK Station Rebuild	3,490,000	4,005
South			
92013600	Bell's Corners Station Rebuild	2,140,506	16,801
92008485	Merivale DS Rebuild	1,630,565	63,343
92012236 - Station Minor Assets Renewal		**60,400**	
All			
92013594	Station Battery Replacement - 2019	40,000	929
West			
92012815	Kanata MTS - RTU Replacement	20,400	152
92099902 - Capacity Upgrades		**16,179,015**	
92003519 - Stations Capacity Upgrades		**16,179,015**	
Central			
92013598	Riverdale New Switchgear	121,392	24,830
East			
92011956	Uplands MS Second Transformer (Island)	5,163,241	13,603
South			
92008537	New South 28kV Substation Yr 1-7	4,314,382	213,716
West			
92012755	Bridlewood Station Rebuild	5,700,000	45,186
92008593	Richmond South DS	880,000	338,717
92099903 - Stations Enhancements		**500,000**	
92000044 - Stations Enhancements		**500,000**	
All			
92001012	Station Replacement	500,000	-
92099926 - OH Distribution Assets Renewal		**8,407,350**	
92000021 - Pole Renewal		**8,332,350**	
All			
92013602	2019 Critical Pole Replacement	2,000,000	-
Central			
92013610	Kirkwood/Hilson Pole Replacement	400,000	294
92011896	Centretown West Pole Repl. 1.4	236,730	2,366
92010275	Britannia Bay Phase 1	750,000	2,594
East			
92013578	Hawthorne b/w Louiseize Rd and Leitrim Pole Replacement	365,780	2,398
92013580	Hawthorne/ Whyte Side Rd Pole Replacement Project	221,175	1,122
92013582	Elmvale Are Pole Replacement Phase 3	1,971,000	22,865
92012775	Elmvale Area Pole Replacement Phase 2	1,969,664	8,044
West			
92012761	44F1 Egress Pole Replacement	418,000	2,804
92000022 - Insulator Renewal		**75,000**	
South			
92012781	Pole Fire Prevention Program - South	75,000	7,056
92099927 - Distribution Enhancement		**7,736,986**	
92001886 - Line Extensions		**1,359,000**	
West			
92012767	TFXF1 Extension (CTC LT)	209,000	12,461
92010741	Shea Re-Stringing	1,150,000	26,470
92002622 - System Voltage Conversion		**4,430,758**	
West			
92010922	Richmond Voltage Conversion - Perth East	979,535	3,355
92010956	Richmond Voltage Conversion - Fortune	890,000	231
92013664	Richmond Voltage Conversion Cut-Overs	200,000	2,318
92012769	Glen Cairn Voltage Conversion - Phase 3	1,212,000	20,576
92013584	Stittsville Main (Abbott/Fernbank Tie)	1,145,000	4,717
92013604	Fringewood Voltage Conversion	4,223	276
92002626 - Distribution System Reliability		**517,742**	

All			
92009223	Worst Feeder Betterment 2013-2020	150,000	93,144
East			
92011992	East 44kV Loop Automation	367,742	6,226
92003370 - Distribution Enhancements		**1,429,487**	
All			
92012307	72F1 Reconfiguration	338,056	-
92009227	Level C Design Time	200,000	-
92001781	CANBAN - Low Value Truck Stock	450,000	4,629
Central			
92011914	Motorize Vector Switches	143,351	3,023
East			
92013606	Casselman New Feeder Egress	298,080	4,381
92099941 - Grid Technologies		**3,915,906**	
92000045 - SCADA Upgrades		**795,906**	
All			
92010422	SCADA Replacement Project	795,906	-
92000046 - RTU Upgrades		**20,000**	
All			
92005506	Minor Enhancements Year 1-5 (Comm upgrades)	20,000	174
92012240 - Communication Infrastructure		**3,100,000**	
All			
92010414	Telecommunications Master Plan	3,100,000	-
92099958 - UG Distribution Assets Renewal		**9,283,574**	
92001363 - Civil Renewal		**520,200**	
All			
92013666	2019 Manhole Rehab	520,200	-
92001856 - Cable Renewal		**6,335,057**	
West			
92012771	Glen Cairn Voltage Conversion - Phase 4	5,284,557	11,789
92012028	Kakulu Rd Trunk (S51-S62)	1,050,500	1,941
92001859 - UG Switchgear Renewal		**532,200**	
West			
92013614	S642 SG Replacement	101,500	1,475
92013616	S340 SG Replacement	215,200	1,364
92013618	S292 SG Replacement	215,500	1,576
92012230 - UG Transformer Renewal		**396,117**	
South			
92011930	Malvern XFRM Replacement (Sherway, Tedwyn)	396,117	1,075
92012232 - Cable Rejuvenation		**1,500,000**	
All			
92013622	2019 Cable Injection	1,500,000	-
92099959 - Plant Failure		**5,500,000**	
92002191 - Distribution Plant Failure		**5,393,000**	
All			
92002191	Distribution Plant Failure	5,393,000	-
92003580 - Station Plant Failure		**107,000**	
All			
92004361	Stations Plant Failure	107,000	-
92099991 - Metering		**1,000,000**	
92003564 - Remote Disconnected Smrt Meter		**1,000,000**	
All			
92003564	Remote Disconnected Smrt Meter	1,000,000	-
Grand Total		**66,393,555**	**1,046,499**

***Project values provided are based on present-day forecasts, as Hydro Ottawa does not maintain records for historical project values.**

****Projects without values have business cases outside of C55 value framework or are placeholders for future work with unknown value (eg. Distribution Plant Failure)**

Scenario: 2019 Board Approved Budget List In Dollars

Parent/Program/Project		Budget	Value ($K)
		20,000	
92099991 - Metering		**20,000**	
All			
9202013996	ION Communications Upgrade	20,000	-
92099901 - Station Assets Renewal		**14,050,324**	
92002614 - Station Transformer Renewal		**1,014,756**	
Central			
92013592	Bayswater Transformer Replacement	588,000	6,596
92011890	Shillington Transformer Replacement	300,000	11,950
92008661	XFRM Repl. Bronson SBT1 & SBT2	126,756	22,043
92003371 - Stations Switchgear Renewal		**3,820,773**	
East			
92010241	Overbrook Switchgear Replacement	3,820,773	20,352
92003405 - Station P&C Renewal		**120,000**	
Central			
92011894	Slater TS relay replacement	120,000	5,249
92012234 - Station Major Assets Renewal		**8,854,795**	
Central			
92013596	Clifton UL Station Rebuild	1,593,724	8,283
92012741	Fisher AK Station Rebuild	3,490,000	4,005
South			
92013600	Bell's Corners Station Rebuild	2,140,506	16,801
92008485	Merivale DS Rebuild	1,630,565	63,343
92012236 - Station Minor Assets Renewal		**240,000**	
All			
92013594	Station Battery Replacement - 2019	40,000	929
West			
92012815	Kanata MTS - RTU Replacement	200,000	152
92099902 - Capacity Upgrades		**16,609,015**	
92003519 - Stations Capacity Upgrades		**13,479,015**	
Central			
92013598	Riverdale New Switchgear	121,392	24,830
East			
92011956	Uplands MS Second Transformer (Island)	5,163,241	13,603
92000004	Limebank MTS 4th Transformer	3,000,000	6,301
South			
92008537	New South 28kV Substation Yr 1-7	4,314,382	213,716
West			
92008593	Richmond South DS	880,000	338,177
9202014015 - Distribution Capacity Upgrades		**3,130,000**	
East			
9202014078	South East Leitrim Capacity	2,000,000	-
South			
9202014072	LMBF3 Ext. Phase 2	1,130,000	6,739
92099903 - Stations Enhancements		**500,000**	
92000044 - Stations Enhancements		**500,000**	
All			
92001012	Station Replacement	500,000	-
92099926 - OH Distribution Assets Renewal		**6,770,151**	
92000021 - Pole Renewal		**6,446,828**	
Central			
9202014061	Centretown West Pole Repl. 1.8 - Percy	906,501	4,019
9202014065	Parnell Pole Replacement	240,000	136
92011904	Centretown West Pole Repl. 1.8 - Bay	1,574,372	5,166
92010275	Britannia Bay Phase 1	750,000	2,594
East			
92013578	Hawthorne b/w Louiseize Rd and Leitrim Pole Replacement	365,780	2,398
92013580	Hawthorne/ Whyte Side Rd Pole Replacement Project	221,175	1,122
92013582	Elmvale Are Pole Replacement Phase 3	1,971,000	22,865
West			
92012761	44F1 Egress Pole Replacement	418,000	2,804
92000022 - Insulator Renewal		**8,323**	
South			
92012781	Pole Fire Prevention Program - South	8,323	7,056
92001860 - OH Switch/Recloser Renewal		**315,000**	
Central			
92013632	TD01 Porcelain Repl & Re-fuse	315,000	324
92099927 - Distribution Enhancement		**8,517,764**	
92002622 - System Voltage Conversion		**4,881,535**	
West			
92010922	Richmond Voltage Conversion - Perth East	979,535	3,355

92010956	Richmond Voltage Conversion - Fortune	890,000	231
92013664	Richmond Voltage Conversion Cut-Overs	200,000	2,318
92012769	Glen Cairn Voltage Conversion - Phase 3	1,212,000	20,576
92013604	Fringewood Voltage Conversion	1,600,000	276
92002626 - Distribution System Reliability		**1,956,742**	
All			
92009223	Worst Feeder Betterment 2013-2020	150,000	93,144
East			
92011992	East 44kV Loop Automation	367,742	6,226
West			
92012767	TFXF1 Extension (CTC LT)	209,000	12,461
92010741	Shea Re-Stringing	1,230,000	26,470
92003370 - Distribution Enhancements		**1,679,487**	
All			
9202014021	Ion Interval - Customer Upgrade	250,000	-
92012307	72F1 Reconfiguration	338,056	-
92009227	Level C Design Time	200,000	-
92001781	CANBAN - Low Value Truck Stock	450,000	4,629
Central			
92011914	Motorize Vector Switches	143,351	3,023
East			
92013606	Casselman New Feeder Egress	298,080	4,381
92099941 - Grid Technologies		**4,620,447**	
92000045 - SCADA Upgrades		**795,906**	
All			
92010422	SCADA Replacement Project	795,906	-
92000046 - RTU Upgrades		**20,000**	
All			
92005506	Minor Enhancements Year 1-5 (Comm upgrades)	20,000	174
92012240 - Communication Infrastructure		**3,804,541**	
All			
92010414	Telecommunications Master Plan	3,804,541	-
92099958 - UG Distribution Assets Renewal		**6,846,356**	
92001363 - Civil Renewal		**520,200**	
All			
92013666	2019 Manhole Rehab	520,200	-
92001856 - Cable Renewal		**5,203,000**	
East			
	77M6 - Phase 2 Cable Replacement	1,860,000	6,228
92013738	77M6 - Phase1 Cable Replacement	1,252,500	6,075
92008609	Blackburn 4F8 - Phase 4A	1,040,000	2,607
West			
92012028	Kakulu Rd Trunk (S51-S62)	1,050,500	1,941
92001859 - UG Switchgear Renewal		**430,700**	
West			
92013616	S340 SG Replacement	215,200	1,364
92013618	S292 SG Replacement	215,500	1,576
92012230 - UG Transformer Renewal		**692,456**	
South			
92013620	XFRMs on Banner Road	296,339	775
92011930	Malvern XFRM Replacement (Sherway, Tedwyn)	396,117	1,075
92099959 - Plant Failure		**7,393,000**	
92002191 - Distribution Plant Failure		**7,393,000**	
All			
92002191	Distribution Plant Failure	7,393,000	-
92003580 - Station Plant Failure		**107,000**	
All			
92004361	Stations Plant Failure	107,000	-
92099991 - Metering		**1,000,000**	
92003564 - Remote Disconnected Smrt Meter		**1,000,000**	
All			
92003564	Remote Disconnected Smrt Meter	1,000,000	-
Grand Total		**66,327,057**	**1,010,458**

INTERROGATORY RESPONSE - SEC-43

2-SEC-43

EXHIBIT REFERENCE:

Ex.2-4-3, p.129

SUBJECT AREA: Distribution System Plan

Please explain how Hydro Ottawa re-assesses and re-prioritizes projects on an annual basis.

RESPONSE:

Hydro Ottawa re-assesses and re-prioritizes projects on an annual basis as laid out below:

1. A preliminary project estimate (Level 'A' - +100%/-50%) is prepared including new projects, existing proposed projects, and multi-year projects.
    - New projects are identified, as described in Exhibit 2-4-3: Distribution System Plan as follows: section 5.2.1 - Project Concept definition; section 5.2.2 - Project Evaluation; and section 5.2.3 - Project Review.
    - Existing proposed projects move through the Project Evaluation and Project Review phases again to confirm that they are still relevant.
    - Multi-year project budgets are reviewed.
2. The project list is prioritized based on Level 'A' estimates, as described in Exhibit 2-4-3: Distribution System Plan, section 5.2.4 - Project Optimization, resulting in a Preliminary Project List.
3. The Preliminary Project List receives approval from the Manager of Asset Planning, after consultation with other key stakeholders.
4. The projects are assigned to a Project Manager to create a Level 'D' estimate (+15%/-5% for distribution projects) or Level 'B' (+75%/-25% for substation projects).
5. The Preliminary Project List moves through the Project Optimization process once more, based on updated project estimates. The list is further refined based on resource

constraints as well as known ongoing expenditures carrying forward into the following year, resulting in a Detailed Project List.

6. The Detailed Project List of prioritized investments is reviewed by multiple stakeholders and is approved by the Manager of Asset Planning. The program level summary of the Detailed Project List is subsequently submitted for approval from Hydro Ottawa's Executive Management Team and Board of Directors. Thereafter, the projects transition into execution.

INTERROGATORY RESPONSE - SEC-44

2-SEC-44

EXHIBIT REFERENCE:

Ex.2-4-3. p.137

SUBJECT AREA: Distribution System Plan

Please confirm that Figures 6.1 and 6.2 shows the overall percentage of assets in each age demographic/asset condition as a percentage of number of assets.

RESPONSE:

Yes, Hydro Ottawa confirms that both Figures 6.1 and 6.2 show the overall percentage of assets in each age demographic/asset condition as a percentage of number of assets.

In Figure 6.1, the number in brackets represents the number of assets in each category. In Figure 6.2, the percentages shown above each bar are based on the total number of assets examined.

INTERROGATORY RESPONSE - SEC-45

2-SEC-45

EXHIBIT REFERENCE:

Ex.2-4-3. p.136-255

SUBJECT AREA: Distribution System Plan

Please complete the attached excel spreadsheet.

RESPONSE:

Please see Attachment SEC-45(A): Asset Conditions. Please note that assets with “No Data” are not included in the denominator of the overall asset condition, as noted in Exhibit 2-4-3: Distribution System Plan, Section 3 (pages 135-255).

As per Attachment 2-4-3(G): Strategic Asset Management Plan, Section 5.3 Asset Condition (pages 21-22) and Section 6 Asset Management (page 35), the utility will continue to gather data on assets which currently have “No Data” available.

INTERROGATORY RESPONSE - SEC-46

2-SEC-46

EXHIBIT REFERENCE:

Ex.2-4-3, p.272

SUBJECT AREA: Distribution System Plan

Please explain what is the cause of the significant increase in the 'Functional Obsolesces' spending driver category.

RESPONSE:

Please see the response to interrogatory OEB-104 part (a).

INTERROGATORY RESPONSE - SEC-47

2-SEC-47

EXHIBIT REFERENCE:

2-4-3, p.313

SUBJECT AREA: Distribution System Plan

Is the Metering Renewal program an entirely new set of activities or just collected under a new program? If it is just a new program, please explain what previous capital programs from the 2016-2020 Custom IR application were the activities previously a part of.

RESPONSE:

The Metering Renewal program is a new set of programs for this Application. For further details, please see the response to interrogatory OEB-60.

INTERROGATORY RESPONSE - SEC-48

2-SEC-48

EXHIBIT REFERENCE:

Ex.2-4-3

SUBJECT AREA: Distribution System Plan

Please update the following Tables 8.2 and 8.4 to include 2019 actuals.

RESPONSE:

Table A includes updates for 2019 actuals for Table 8.2.

Table A – Capital Expenditure Historical Summary ($'000s)

Investment Category	Historical								Bridge	
	2016		2017		2018		2019		2020	
	Act.	Var.	Act.	Var.	Act.	Var.	Act.	Var.	Act.*	Var.
System Access	$37,805	(3%)	$30,908	(12%)	$40,849	16%	$49,259	37%	$53,331	46%
System Renewal	$42,639	12%	$43,816	46%	$54,942	59%	$30,478	(11%)	$32,048	(5%)
System Service	$17,783	(21%)	$24,844	(30%)	$29,801	(5%)	$25,850	(20%)	$31,378	(11%)
General Plant	$20,323	(56%)	$38,300	(20%)	$56,738	210%	$35,080	88%	$42,580	205%
Total Capital Expenditures	**$118,550**	**(18%)**	**$137,868**	**(8%)**	**$182,330**	**53%**	**$140,667**	**16%**	**$159,337**	**33%**
Capital Contributions	**$(19,491)**	(18%)	$(17,315)	(25%)	$(16,742)	(27%)	$(24,816)	6%	$(33,354)	40%
Net Capital Expenditures	**$99,058**	**(19%)**	**$120,552**	**(4%)**	**$165,588**	**72%**	**$115,851**	**19%**	**$125,983**	**32%**

(*) 2020 Forecast based on Budget not Actuals

Table B below includes 2019 actuals for Table 8.4 (Historical and Bridge Years).

Table B – 2016-2020 Expenditures by Investment Category ($'000s)

Investment Category	Historical				Bridge	Var.
	2016	2017	2018	2019	2020	
	Act.	Act.	Act.	Act.	Act.*	
System Access	$37,805	$30,908	$40,849	$49,259	$53,331	$42,430
System Renewal	$42,639	$43,816	$54,942	$30,478	$32,048	$40,785
System Service	$17,783	$24,844	$29,801	$25,850	$31,378	$25,931
General Plant	$20,323	$38,300	$56,738	$35,080	$42,580	$38,604
Total Capital Expenditures	**$118,550**	**$137,868**	**$182,330**	**$140,667**	**$159,337**	**$147,750**
Capital Contributions	$(19,491)	$(17,315)	$(16,742)	$(24,816)	$(33,354)	$(22,344)
Net Capital Expenditures	**$99,058**	**$120,552**	**$165,588**	**$115,851**	**$125,983**	**$125,406**

(*) 2020 Forecast based on Budget not Actuals

Table C provides updates to Table 8.4 (Test Years) to reflect 2019 actuals.

Table C – 2021-2025 Expenditures by Investment Category ($'000s)

Investment Category	Test					Var.
	2021	2022	2023	2024	2025	
System Access	$56,693	$41,032	$37,434	$34,462	$34,039	$40,732
System Renewal	$43,296	$44,012	$40,191	$39,436	$40,474	$41,482
System Service	$26,659	$28,318	$24,337	$25,155	$23,899	$25,674
General Plant	$32,047	$11,681	$7,556	$17,354	$16,884	$17,104
Total Capital Expenditures	**$158,695**	**$125,043**	**$109,518**	**$116,407**	**$115,296**	**$124,992**
Capital Contributions	$(39,232)	$(23,493)	$(19,943)	$(19,226)	$(19,264)	$(24,232)
Net Capital Expenditures	**$119,463**	**$101,550**	**$89,575**	**$97,181**	**$96,032**	**$100,760**

INTERROGATORY RESPONSE - SEC-49

2-SEC-49

EXHIBIT REFERENCE:

Ex.2-4-3, Attach A

SUBJECT AREA: Distribution System Plan

Please provide a version of Appendix 2-AA on an in-service additions basis.

RESPONSE:

Please see Attachment SEC-49(A): Appendix 2-AA with In-service Additions.

INTERROGATORY RESPONSE - SEC-50

2-SEC-50

EXHIBIT REFERENCE:

Ex.2-4-3, p.335

SUBJECT AREA: Distribution System Plan

Please explain why Hydro Ottawa classifies capital contribution payments to Hydro One as General Plant expenditures.

RESPONSE:

Hydro Ottawa classifies capital contribution payments to Hydro One Networks as General Plant expenditures in accordance with OEB *Chapter 5 Filing Requirements for Electricity Distribution Rate Applications* ("Chapter 5 Filing Requirements"). Table A below is an excerpt from page 6 of the Chapter 5 Filing Requirements, where the last row indicates that intangibles such as capital contributions to other utilities should be classified as General Plant.

Table A – Investment Categories & Example Drivers & Projects/Programs

	Example Drivers	Example Projects / Programs
System Access	Customer service requests	- New customer connections - Modifications to existing customer connections - Expansions for customer connections or property development
	Other 3rd party infrastructure development requirements	- System modifications for property or infrastructure development (e.g. relocating pole lines for road widening)
	Mandated service obligations (DSC; Cond. of Serv.; etc.)	- Metering - Long term load transfer
System Renewal	Assets/asset systems at end of service lids due to: - Failure - Failure risk - Substandard performance - High performance risk - Functional obsolescence	- Programs to refurbish/replace assets or asset systems; e.g.: batteries, cable (by type); cable splices; civil works; conductor; elbows & inserts; insulators; poles (by type); physical plant; relays; switchgear; transformers (by type); other equipment (by type)
System Service	Expected changes in load that will constrain the ability of the system to provide consistent services delivery	- Property acquisition - Capacity upgrade (by type); e.g. phase; circuits; conductor; voltage; transformation; regulation - Line extensions
	System operational objectives; - Safety - Reliability - Power quality - System efficiency - Other performance/functionality	- Protection & control upgrade; e.g. reclosers; tap changer controls/relays; transfer trip - Automation (new/upgrades) by device type/function - Supervisory control and data acquisition (SCADA) - Distribution loss reduction
General Plant	- System capital investment support - System maintenance support - Business operations efficiency - Non-system physical plant	- Land acquisition - Structures & depreciable improvements - Equipment and tools - Supplies - Finance/admin/billing software & systems - Rolling stock - Intangible (e.g. land rights; capital contributions to other utilities)

INTERROGATORY RESPONSE - SEC-51

2-SEC-51

EXHIBIT REFERENCE:

Ex.2

SUBJECT AREA: Distribution System Plan

Please provide step-by-step details regarding how Hydro Ottawa forecasts individual project costs. Please provide examples to illustrate.

RESPONSE:

Please refer to pages 107-130 of Exhibit 2-4-3: Distribution System Plan for step-by-step details of Hydro Ottawa's capital expenditure planning process. Please see Attachment 2-4-3(E): Material Investments for detailed examples.

INTERROGATORY RESPONSE - SEC-52

2-SEC-52

EXHIBIT REFERENCE:

[Ex.2]

SUBJECT AREA: Distribution System Plan

Please provide step-by-step details regarding how Hydro Ottawa forecasts individual programs costs. Please provide examples to illustrate.

RESPONSE:

Please refer to pages 107-130 of Exhibit 2-4-3: Distribution System Plan for step-by-step details of Hydro Ottawa's capital expenditure planning process. Please see Attachment 2-4-3(E): Material Investments for detailed examples.

INTERROGATORY RESPONSE - SEC-53

2-SEC-53

EXHIBIT REFERENCE:

[Ex.2]

SUBJECT AREA: Distribution System Plan

Question:

Please explain how Hydro Ottawa translates the annual capital expenditures into in-service additions.

RESPONSE:

Actual capital expenditures are recorded into each applicable project work order in Hydro Ottawa's accounting system, and are recorded as construction in progress ("CIP"). Each work order is monitored by a project manager. Upon completion of each project, as well as when the assets are energized, the project manager notifies the accounting department to capitalize the capital cost into in-service additions (property, plant and equipment).

With respect to the forecast assumptions between capital expenditures and capital additions, please see part (b) of the response to interrogatory OEB-187.

INTERROGATORY RESPONSE - SEC-54

2-SEC-54

EXHIBIT REFERENCE:

[Ex.2-4-3, Attachment D]

SUBJECT AREA: Distribution System Plan

Question:

With respect to the Navigant, Independent Assessment of Hydro Ottawa's Distribution System Plan:

a) Please provide a copy of the retainer and any other instructions provided to Navigant.

b) Please provide the CV of Mr. Shaltz, and include a list (including docket numbers) for all other expert testimony he has provided to courts or regulators related to utility capital planning or related engagements.

c) Please provide a copy of all recommendations provided to Hydro Ottawa.

d) Please confirm that the only Hydro Ottawa information that Navigant based its assessment on are draft versions of the three documents listed on page 1. If this is not confirmed, please provide details and copies of all documents/interview notes/data, etc. that Navigant reviewed, if not already contained in the application.

RESPONSE:

a) A copy of the executed agreement between Hydro Ottawa and Navigant is appended in Attachment SEC-54(A): Fully Executed Agreement for Assessment of DSP.

b) Attachment SEC-54(B): Navigant - Hydro Ottawa - Independent Review of DSP contains Navigant's proposal, including the CV of Mr. Shaltz, as well as Navigant's team experience and qualifications in utility capital planning and related engagements.

c) Please see Attachment SEC-54(C): Navigant First Review and Attachment SEC-54(D): Navigant Second Review for recommendations provided to Hydro Ottawa by Navigant.

d) Hydro Ottawa confirms that Navigant based its assessments on draft versions of the three documents listed on page 1.

PROFESSIONAL SERVICES AGREEMENT

This Professional Services Agreement ("**Agreement**") effective April 1, 2019, between Hydro Ottawa Limited, a corporation incorporated under the laws of the Province of Ontario ("**Hydro Ottawa**") and Navigant Consulting Ltd. (the "**Consultant**").

BACKGROUND:

A. Hydro Ottawa requires a consultant to provide an Independent Assessment of Hydro Ottawa's Distribution System Plan. (the "Services").
B. The Consultant has demonstrated that it has a thorough understanding of Hydro Ottawa's objectives and requirements, and is capable of meeting those objectives and requirements through it services.

AGREEMENT:

IN CONSIDERATION of the foregoing and the mutual covenants contained in this Agreement and other good and valuable consideration, the parties agree:

1. **Services**
   a. The Consultant shall complete the Services described in "**Schedule A**" for Hydro Ottawa.
   b. The Consultant shall take commercially reasonable steps to obtain any interpretation or clarification of any requested Services, prior to the commencement of the Services.

2. **Subcontractors**
   In providing the Services contracted for under this Agreement, the Consultant shall act as a single point-of-accountability vendor and shall assume complete and overall contractual responsibility for the provision of the Services and related activities and provide for all ongoing product and performance warranties to the extent set out in this Agreement. "**Subcontractors**" means any third party under contract with the Consultant to provide the Services under this Agreement. The provision of any Services by any of the Consultant's Subcontractors or employees of affiliates shall not in any way whatsoever release or discharge the Consultant or derogate from the covenants, representations and warranties provided by the Consultant under this Agreement. Notwithstanding the provision of Services by any Subcontractors or employees of affiliates, the sole responsibility for the provision of all Services during the Term lies with the Consultant and in no event shall Hydro Ottawa be compelled to pursue remedy against any of the Consultant's Subcontractors or employees of affiliates. Consultant will be authorized to use employees of affiliates (being a legal entity controlling or under common control of Consultant: control refers to the possession, directly or indirectly of the power to direct or cause the direction of the management of a legal entity, whether through the ownership of voting securities, by contract or otherwise) of Consultant to execute the Services.
3. **Term**
   a. This Agreement is effective as set out above and shall continue until July 31, 2019 (the **"Term"**), unless terminated earlier in accordance with the terms herein.

4. **Fees**
   a. The Consultant shall be paid for provided Services during the Term in accordance with the Fee Schedule set out in "**Schedule B".**
   b. Hydro Ottawa will reimburse the Consultant for pre-approved travel, meal and accommodation expenses in accordance with **Appendix 1 to Schedule B – Hydro Ottawa Expense Policy.**
   c. The Consultant shall issue invoices in accordance with the Payment Milestone Schedule included in **Schedule B**.
   d. Payment shall be rendered in accordance with **Schedule B**.
   e. The Consultant shall ensure that the HST amount and the HST registration number must appear on all invoices from the Consultant to Hydro Ottawa. The Consultant shall be solely responsible for any and all taxes, employment insurance contributions or payments, disability insurance, and other payroll type taxes applicable to such compensation. The Consultant hereby indemnifies and holds Hydro Ottawa harmless from, any claims, losses, costs, fees, liabilities, damages or

injuries suffered by Hydro Ottawa arising out of the Consultant's failure with respect to its obligations in this section.

5. Representations and Warranties:

a. The Consultant represents and warrants to Hydro Ottawa as follows:

i. Status. The Consultant is duly constituted, validly existing and in good standing under the laws of its governing jurisdiction.

ii. Authority. The Consultant has the necessary power, authority, capacity and good and sufficient right to enter into this Agreement on the terms and conditions herein set forth, and the execution and performance of this Agreement will not conflict with, or constitute a breach under, any agreement to which it is a party or any judgment, order, statute or regulation which is applicable to the Consultant.

iii. Experience and Financial Capacity. The Consultant understands the requirements of Hydro Ottawa as set out in this Agreement and that it possesses the skills, know-how and ability to satisfactorily meet such requirements in the provision of the Services to the standards required in this Agreement. The Consultant has the experience, ability and financial capacity to perform and fulfill its obligations hereunder, and covenants to maintain during the Term, the financial and other ability and authority to perform and fulfill its obligations hereunder.

iv. Quality of Services. The Services shall be provided fully and diligently in a professional and competent manner by persons qualified and skilled in their occupations and all Services will be provided in accordance with the Agreement, industry standards and in accordance with applicable law.

v. Conflict of Interest. The Consultant has no interest and will not acquire any interest, direct or indirect, which would conflict in any manner or degree with the performance of service under this Agreement.

6. Confidential Information

a. Hydro Ottawa owns and will hereafter develop, compile and own certain proprietary techniques, trade secrets, and confidential information which have great value in its business (collectively, **"Hydro Ottawa Information"**). Hydro Ottawa will be disclosing Hydro Ottawa Information to the Consultant during the Consultant's performance of the Services. Hydro Ottawa Information includes not only information disclosed by Hydro Ottawa, but also information developed or learned by the Consultant during the Consultant's performance of the Services. Hydro Ottawa Information is to be broadly defined and includes all information which has or could have commercial value or other utility in the business in which Hydro Ottawa is engaged or contemplates engaging or the unauthorized disclosure of which could be detrimental to the interests of Hydro Ottawa, whether or not such information is identified by Hydro Ottawa. By way of example and without limitation, Hydro Ottawa Information includes any and all information concerning discoveries, developments, designs, improvements, inventions, formulas, software programs, processes, techniques, know-how, data, research techniques, customer and supplier lists, marketing, sales or other financial or business information, scripts, and all derivatives, improvements and enhancements to any of the above. Hydro Ottawa Information also includes third-party information which is in Hydro Ottawa's possession under an obligation of confidential treatment.

b. **Protection of Hydro Ottawa Information**. The Consultant agrees that at all times during or subsequent to the performance of the Services, the Consultant will keep confidential and not divulge, communicate, or use Hydro Ottawa Information, except for the Consultant's own use during the Term of this Agreement to the extent necessary to perform the Services.

c. **Exceptions.** The Consultant's obligations with respect to any portion of the Hydro Ottawa Information as set forth above shall not apply when the Consultant can document that:

i. It was in the public domain at the time it was communicated to the Consultant by Hydro Ottawa;

ii. It entered the public domain subsequent to the time it was communicated to the Consultant by Hydro Ottawa through no fault of the Consultant;

iii. It was in the Consultant's possession free of any obligation of confidence at the time it was communicated to the Consultant by Hydro Ottawa; or
iv. It was rightfully communicated to the Consultant free of any obligation of confidence subsequent to the time it was communicated to The Consultant by Hydro Ottawa.

d. **Hydro Ottawa Property.** All materials, including without limitation documents, drawings, drafts, notes, designs, computer media, electronic files and lists, including all additions to, deletions from, alterations of, and revisions in the foregoing (together the **"Materials"**), which are furnished to the Consultant by Hydro Ottawa or which are developed in the process of performing the Services, or embody or relate to the Services, the Hydro Ottawa Information or the Work Product (as defined below), are the property of Hydro Ottawa, and shall be returned by the Consultant to Hydro Ottawa promptly at Hydro Ottawa's request together with any copies thereof, and in any event promptly upon expiration or termination of this Agreement for any reason. Notwithstanding the foregoing the Consultant shall be entitled to retain one copy by an authorized legal representative of Consultant solely for purposes of assuring compliance hereunder and except that automatically backed-up Ottawa Hydro Information as stored on Consultant's electronic data systems shall not be required to be deleted or returned to Hydro Ottawa. The Consultant is granted no rights in or to such Materials, the Hydro Ottawa Information or the Work Product, except as necessary to fulfill its obligations under this Agreement. The Consultant shall not use or disclose the Materials, Hydro Ottawa Information or Work Product to any third party.

e. **Terms of this Agreement.** The parties agree that the terms of this Agreement shall be treated as confidential and shall not be disclosed to any third party unless the disclosure and/or use of such information is consented to in writing by the party who initially provided the information that is to be disclosed or unless it is required by law. In the event that the disclosure and/or use are required by law, such disclosure/use shall be limited to the extent of that requirement.

7. Ownership of Work Product

a. The Consultant will promptly disclose in writing to Hydro Ottawa all works, products, discoveries, developments, designs, innovations, improvements, inventions, formulas, processes, techniques, know-how and data (whether or not patentable, and whether or not at a commercial stage, or registrable under copyright or similar statutes) which are authored, made, conceived, reduced to practice or learned in relation to the Services and provided by the Consultant (either alone or jointly with others) during the period the Consultant provides the Services including any concepts, ideas, suggestions and approaches related thereto or contained therein (collectively, the **"Work Products"**).

b. Hydro Ottawa shall own all Work Product arising during the course of the Consultant's obligations to Hydro Ottawa under this Agreement.

c. Each party and/or their respective licensors shall retain ownership of all Intellectual Property, that is: (i) proprietary to that party or which a party has a right to sublicense to the other party; and (ii) was created, conceived or developed prior to, or independent of the Consultant's work for Hydro Ottawa ("Pre-Existing Intellectual Property"). To the extent the Consultant's reports or other documents delivered to Hydro Ottawa contain Pre-Existing Intellectual Property, the Consultant grants Hydro Ottawa a non-exclusive, non-assignable, royalty-free license to use it in connection with the purpose of this Agreement. The Consultant agrees to take such actions and execute such further acknowledgments and assignments as Hydro Ottawa may reasonably request to give effect to this provision.

8. Intellectual Property:

a. Hydro Ottawa hereby grants the Consultant a limited, revocable, non-exclusive, non-transferable license during the Term:
i. to use the Hydro Ottawa Intellectual Property related to the Services as required and as contemplated by this Agreement; and
ii. to use Hydro Ottawa Marks (defined below) in connection with the Services, in marketing materials related to the Services or as otherwise agreed by the Parties and as pre-approved by Hydro Ottawa.

iii. For the purpose of this Agreement, "**Marks**" means the trademarks, including registered and common law trademarks, trade names, service marks, logos, domain names and designations owned, licensed or used by Hydro Ottawa.

b. The Consultant and Subcontractors will have the right to use the Hydro Ottawa Marks only in connection with the Services and only in a manner and form approved in advance in writing by Hydro Ottawa, which approval shall not be unreasonably withheld or delayed. All use of the Hydro Ottawa Marks shall enure to the benefit of Hydro Ottawa. All right, title and interest in and to the Hydro Ottawa Marks remain with Hydro Ottawa and upon termination of the Agreement for any reason, the Consultant and Subcontractors will have no further right to use the Hydro Ottawa Marks and will immediately cease and desist use of them.

c. Hydro Ottawa may terminate a foregoing license granted to the Consultant if, in its reasonable discretion, the Consultant's use of the Marks tarnishes, blurs or dilutes the quality associated with the Marks or the associated goodwill and is not in conformance with instructions provided by the licensor, or such problem is not cured within ten (10) Business Days of written notice of breach.

d. For the purpose of this agreement, "Intellectual Property" means :

(i) any and all proprietary rights anywhere in the world provided under: (1) patent law; (2) copyright law (including moral rights); (3) trade-mark law; (4) design patent or industrial design law; (5) semi-conductor chip or mask work or integrated circuit topography law; or (6) any other statutory provision or common law principle applicable to this Agreement, including trade secret law, that may provide a right in either hardware, software, content, documentation, confidential information, trade-marks, ideas, formulae, algorithms, concepts, inventions, processes or know-how generally, or the expression or use of such hardware, software, content, documentation, confidential information, trade-marks, ideas, formulae, algorithms, concepts, inventions, processes or know-how;

(ii) any and all applications, registrations, licences, sub-licences, franchises, agreements or any other evidence of a right in any of the foregoing;

(iii) any and all licences and waivers and benefits of waivers of the intellectual property rights set out in paragraph (i) or any and all applications, registrations, licences, sub-licences, franchises, agreements or any other evidence of a right in any of the foregoing;

(iv) all future income and proceeds from the intellectual property rights set out in paragraphs (i) or (ii) above, and all rights to damages and profits by reason of the infringement or violation of any of the intellectual property rights set out in paragraphs (i) or (ii) above.

9. Personal Information

a. If applicable, the Consultant will: collect, use, disclose, and retain Personal Information only as required to fulfill its obligations pursuant to this Agreement; take appropriate measures to ensure the privacy and security of all Personal Information, including taking measures to prevent unauthorized access, collection, use, disclosure, copying, modification or disposal; and comply with all laws or regulations related to privacy or data protection that are applicable to both Hydro Ottawa and the Consultant. "**Personal Information**" means information about an identifiable individual, including without limitation any information defined or deemed as such pursuant to any applicable laws related to privacy or data protection.

10. Termination

a. Hydro Ottawa may, without liability, terminate this Agreement on ten (10) Business Days' notice to The Consultant.

b. If Hydro Ottawa exercises its right to terminate the Agreement, any obligation it may otherwise have under this Agreement shall cease immediately, except that Hydro Ottawa shall be obligated to compensate Consultant in accordance with Clause 11.a.

c. Notwithstanding subsection 9(a), Hydro Ottawa may terminate this Agreement without notice, act or formality, effective immediately if the Consultant becomes insolvent, makes a general assignment for the benefit of creditors, permits a Receiver to be appointed for its business or assets or becomes subject to any proceedings under the *Bankruptcy and Insolvency Act* or any statute of any provinces, state or other jurisdiction relating to insolvency or the protection of creditor's rights.

d. Where Hydro Ottawa is in default of any provisions of this Agreement, the Consultant may terminate this Agreement on ten (10) Business Days' notice to Hydro Ottawa, unless Hydro Ottawa has cured such default within the ten (10) Business Day period, or is in the process of curing such default within the ten (10) Business Day period, and thereafter diligently curing such default. If the Consultant exercises its right to terminate the Agreement, any obligation it may otherwise have under this Agreement shall cease immediately.

11. Effect of Termination

a. Should this Agreement expire or terminate for any reason, Hydro Ottawa shall pay The Consultant for all the Services rendered prior to termination and for all expenses reasonably and properly incurred by the Consultant prior to termination.
b. The provisions of Sections 2, 4, 6, 7, 8, 9, 14, 15, and 21.b) of this Agreement shall survive any termination of the Agreement.

12. Force Majeure

a. Neither Party shall be liable in damages or have the right to terminate this Agreement for any delay or default in performing hereunder if such delay or default is caused by conditions beyond the Party's control including, but not limited to Acts of God, Government restrictions (including the denial or cancellation of any permits or other necessary license), wars, insurrections, fires, floods or unusually severe weather, disruptions resulting from labour disputes, governmental or regulatory action and/or any other cause beyond the reasonable control of the Party whose performance is affected (**"Force Majeure"**).
b. The performance requirements specified in the Agreement and affected by such causes shall be extended by periods equal to the duration of the event that gave rise to the Force Majeure. The party experiencing an event of Force Majeure or of a situation that might possibly create a situation of Force Majeure shall immediately notify the other party of such event or situation. Acknowledgement of any Force Majeure is subject to the submission by receipt of a written confirmation and reasonable evidence of proof of the events or circumstances forming the basis of the claim regarding Force Majeure.

13. Restricted Locations

a. Certain locations within Hydro Ottawa facilities have restricted access ("**Restricted Locations**") and such Restricted Locations requires enhanced security screening of the Consultant's personnel. Where applicable, and upon reasonable notice, the Consultant will conduct background screening (including, but not limited to, criminal records, employment records, education history, financial and security checks) of its personnel prior to such personnel gaining access to Hydro Ottawa Restricted Locations. When requested by Hydro Ottawa, the Consultant shall provide to Hydro Ottawa criminal background checks acceptable to Hydro Ottawa for all personnel who will be entering or will have access to Hydro Ottawa premises pursuant to this Agreement.

14. Indemnity

a. **Mutual Indemnity.** Each Party (the **"Indemnitor"**) shall indemnify and hold harmless the other (the "**Indemnitee**") against any and all demands, claims, damages, injunctions and penalties of any kind (collectively "**Actions**"), including, without limitation, reasonable legal fees, made by or on behalf of any party arising from the breach by the Indemnitor of any of its obligations under this Agreement or any act of fraud, willful misconduct or negligence of the Indemnitor or those for whom the Indemnitor is at law responsible. No indemnification will be provided by Indemnitor for any of the foregoing Actions, to the extent they are caused by the acts or omissions of the Indemnitee or any of its affiliates or any of their respective employees, contractors or agents.
b. The Indemnitor shall pay any costs and damages finally awarded against the Indemnitee in any such Action to the extent the costs and damages are attributable to the Indemnitor's breach of this Agreement or fraud, willful misconduct or negligence of the Indemnitor. However, such payments are subject to:
    i. The Indemnitee promptly notifying the Indemnitor in writing of the Action;

ii. The Indemnitor may negotiate on behalf of the Indemnitee but must obtain approval from the Indemnitee before accepting any settlements or compromises proposed during negotiation; and
iii. The Indemnitee, where applicable, reasonably assisting the Indemnitor in the defence of any such Action.

15. Liability

a. **Limitation of Liability.** Regardless of how such liability arises or is based, whether in contract or in tort and even if based on negligence, misrepresentation, breach of warranty or condition and even if based upon a claim of fundamental breach or breach of a fundamental term, the parties will be liable to one another with respect to direct losses arising in the course of the performance of the party's obligations under this Agreement or arising otherwise in connection with the Agreement, for an aggregate amount that will not exceed the total amount payable by Hydro Ottawa under this Agreement.
b. Notwithstanding the foregoing, no exclusion or limitation of liability shall apply to:
   i. Breach of the confidentiality obligations in this Agreement;
   ii. Intentional misconduct;
   iii. Injury to tangible property or bodily injury due to negligent, willful, or malicious conduct by either party; or
   iv. Breach of applicable laws;
c. **No Liability for Indirect Damages.** Neither party shall have any liability for indirect or consequential, exemplary, punitive, lost profits, lost savings, lost revenue, or special damages whether in contract, tort, negligence, or otherwise and whether or not foreseeable.

16. Insurance

a. **Commercial General Liability Insurance.** The Consultant shall maintain comprehensive commercial general liability insurance in the minimum amount of two million dollars ($2,000,000) CAD per occurrence, for bodily injury, death, and damage to property including loss of use thereof. The policy shall be endorsed to provide the applicable party with not less than thirty (30) days written notice in advance of cancellation and to show the applicable party as an additional insured.
b. **Automobile Insurance.** Where applicable, the Consultant shall maintain automobile liability insurance in the minimum amount of two million dollars ($2,000,000) CAD, at its own cost, for licensed vehicles owned or operated by the Consultant in Canada.
c. **Proof of Insurance.** Upon request, the either party shall provide certificates of insurance to the requesting party.

17. Independent Contractor

a. Both parties hereto covenant, agree and confirm that they have entered into this Agreement not as employer nor employee, nor in partnership, but merely as independent parties carrying on separate business enterprises. This Agreement does not constitute and shall not be construed as constituting a partnership, joint venture or principal/agency relationship between the parties. The Contractor is and will at all times remain an independent contractor and is not and shall not represent itself to be an agent of the Company. Neither party by virtue of this Agreement shall have the right, power or authority to act or to create any obligations, express or implied, on behalf of the other party.
b. The Contractor acknowledges and agrees that in performing services under this Agreement, the Contractor is responsible for all required taxes, withholdings and remittances or other similar obligations under any federal or provincial legislation that applies to compensation received pursuant to this Agreement. The Contractor acknowledges that all payments made by the Company to the Contractor shall be made without statutory deductions in respect of income tax, Canada Pension Plan, Employment Insurance, Workplace Safety and Insurance, and the Ontario Employers' Health Tax.

18. Acceptance

a. No part of the Services will be accepted unless approved by Hydro Ottawa and Hydro Ottawa is satisfied that the work completed fully complies with the true meaning and intent of the specifications set out in Schedule A. Such acceptance, however, shall not impair any claim that Hydro Ottawa may have for the replacement of defective work or material.
b. All Services provided by the Consultant shall be for use solely for the Hydro Ottawa's internal business purposes and the purpose set forth in this Agreement and not for any other purpose. The Consultant will have no liability to any third-parties who rely upon any such services.

19. Records and Audit

a. The Consultant shall keep proper accounts and records of the cost to the Consultant of the Services provided and of all expenditures or commitments made by the Consultant in connection therewith, and shall keep all books and records including invoices, receipts, vouchers, cheques, relating thereto. The Consultant shall not, without the prior written consent of Hydro Ottawa, dispose of any such accounts, records, invoices, receipts or vouchers until the expiration of 2 years after final payment under this Agreement, or until the settlement of all outstanding claims and disputes, whichever is later.
b. The Consultant shall furnish all such information as the representatives of Hydro Ottawa may from time to time reasonably require with respect to such accounts, records, invoices, receipts and vouchers.

20. Notices

a. All notices required by this Agreement shall be in writing and shall be sent by email, or delivered in person or by prepaid courier, or mailed by certified or registered mail, return receipt requested, with postage prepaid.
b. Notice to the Consultant shall be addressed to: Benjamin Grunfeld, Managing Director, Navigant Consulting Ltd., 333 Bay Street, Suite 1250, Toronto, ON M5H 2R2, benjamin.grunfeld@navigant.com.
c. Notices to Hydro Ottawa shall be addressed to: Farah Butt, Mailing Address: P.O. Box 8700, Ottawa, Ontario K1G 3S4, via Courier until 03 May 2019: 3025 Albion Road North, Ottawa ON, K1G 3S4,after 06 May 2019: 2711 Hunt Club Road Ottawa, ON K1G 5Z9, farahbutt@hydroottawa.com.
d. All notices so sent shall be deemed to have been received by the recipient on the date the transmission was sent, or on the date of delivery or on the second (2nd) Business Day following the mailing thereof. The above address of either the Consultant or Hydro Ottawa may be changed by giving to the other party written notice of the new address.
e. If postal service is interrupted, or threatened to be interrupted, or is substantially delayed, any notice shall only be sent by email or delivered by courier.

21. General:

a. **Headings:** The headings in this Agreement are for convenience only and shall not in any way limit or be deemed to construe or interpret the terms and provisions of this Agreement.
b. **Governing Law:** This Agreement shall be construed and enforced in accordance with laws of the Province of Ontario.
c. **Entire Agreement:** This Agreement embodies the entire agreement of the parties with regard to the matters herein, and no other agreement shall be deemed to exist except as entered into in writing by both parties to this Agreement.
d. **Amendments and Waivers:** No amendment or waiver of any provision of this Agreement shall be binding on either party unless consented to in writing by such party. No waiver of any provision of this Agreement shall constitute a waiver of any other provision, nor shall any waiver constitute a continuing waiver, unless otherwise provided.
e. **Assignment:** The Consultant shall not assign this Agreement or any part of it without obtaining the prior written consent of Hydro Ottawa, which consent may be unreasonably withheld. Hydro

Ottawa shall have the right, at its election, to assign this Agreement to any person, firm or corporation.

f. **Enurement:** This Agreement shall enure to the benefit of and be binding on the parties and their respective heirs, executors, successors and permitted assigns.
g. **Severability:** If any part of this Agreement is held or rendered invalid or illegal, the remainder of this Agreement continues to apply.
h. **Counterparts:** This Agreement may be executed in counterparts, each of which shall constitute an original, and all of which shall constitute one agreement. A portable document format (PDF) copy of an executed counterpart signature page will be as valid as an originally executed counterpart for purposes of signing this Agreement.

IN WITNESS WHEREOF this Agreement has been signed by the duly authorized officers of the parties hereto.

Hydro Ottawa Limited

Name: Ben Hazlett
Title: Manager, Distribution Policies & Standards
Date: MARCH 29, 2019

Navigant Consulting Ltd.

Name: Benjamin Grunfeld
Title: Managing Director
Date: March 27, 2019

SCHEDULE A
STATEMENT OF WORK

1. Introduction

Hydro Ottawa will be submitting its next rate application in December of 2019. The Distribution System Plan (DSP) is included in the rate application. It consolidates the documentation related to the asset management process and capital expenditure plan meeting the requirements laid out in the Ontario Energy Board's Filing Requirements for Electricity Distribution Rate Applications – 2018 Edition for 2019 Rate Applications - , Chapter 5, Consolidated Distribution System Plan, July 12, 2018 (OEB Chapter 5 Filing Requirements).

2. Scope of Work

The intent of this review is to ensure that Hydro Ottawa's DSP and supporting documentation (i.e. Business cases, Asset Management Plans and Strategic Asset Management Plan) meets, or exceeds OEB Chapter 5 Filing Requirements.

The review should accomplish the following objectives:

- Advising whether Hydro Ottawa's DSP aligns with applicable OEB filing requirements;
- Assess how the DSP addresses the OEB's four performance outcomes, customer focus, operational effectiveness, public policy responsiveness, and financial performance;
- Produce a letter that provides a clear and well-documented assessment of our review and comments as to the completeness of the DSP with regards to the OEB's requirements; and,
- Provide regulatory support, if needed, to respond to interrogatories, attend technical conferences and appear before the OEB in oral hearings.

3. Deliverables

- The 1st Review of DSP and supporting documentation (i.e. Strategic Asset Management Plan) to be complete by Navigant within 3 weeks from the date the DSP has been issued from Hydro Ottawa.
- Face to Face meeting to discuss results from 1st DSP review
- The 2nd review of the DSP will be complete by Navigant within 2 weeks from the date the DSP has been issued from Hydro Ottawa.
- Business cases and individual Asset Management Plans review will be complete by Navigant within 4 weeks from the date documents are issued from Hydro Ottawa.
- Review letter providing written confirmation of third-party review

4. Development Stage Schedule

We expect the majority of the work will be completed by the end of July 2019, with the major milestone dates as outlines below:

• Copy of Draft DSP provided to Navigant – March 29, 2019
• Navigant review of Draft DSP complete – April 19, 2019
• Face-to-face meeting – week of April 22, 2019
• Revised DSP provided to Navigant – May 31, 2019
• Navigant review of Revised DSP complete – June 14, 2019
• Program- and project-level business cases provided to Navigant – June 14, 2019
• Navigant's review letter provided to Hydro Ottawa – June 28, 2019
• Navigant review of business cases complete – July 12, 2019

5. Development Methodology

Navigant will provide professional services for the independent review of Hydro Ottawa's DSP and associated business cases. The DSP and associated business cases will include asset renewal, capacity expansion and system upgrades that Hydro Ottawa expects to place into service over the five-year rate period.

Navigant will review and evaluate Hydro Ottawa's DSP and engage, as needed, with Hydro Ottawa's subject matter experts, with the objective of advising on the following:

1. Is Hydro Ottawa's DSP consistent with the guidelines and objectives set forth in Chapter 5 of the OEB's Filing Requirements for Electricity Distribution Rate Applications?
2. How well the DSP addresses the OEB's four performance outcomes, customer focus, operational effectiveness, public policy responsiveness, and financial performance?

The proposed scope of work for this engagement includes five main deliverables.

1. Review Hydro Ottawa's draft DSP and provide markups with suggested changes and comments

    - Navigant will review Hydro Ottawa's draft DSP and supporting documentation (including the company's overarching strategic asset management plan) and recommend changes/provide comments regarding compatibility of its contents with OEB Chapter 5 Filing Requirements and highlight areas that may garner additional inquiries from the OEB or interveners.
    - Navigant will provide comments and recommendations regarding the contents, language and formatting of the draft DSP.

2. Summary of the action items following a face-to-face meeting in Ottawa with Hydro Ottawa Staff

    - Navigant will meet with Hydro Ottawa staff, in Ottawa, to go over recommendations and comments.
    - Provide direction as to how the recommendations should be incorporated in the next version of the DSP with regards to prioritization of gaps or suggestions.

3. Review Hydro Ottawa's program-level (23) and project-level (~20) business cases and individual asset category asset management plans (13) that support the investment outlined in the DSP and provide markups and suggested changes and comments

4. Provide written recommendation following a second review, once changes to the original draft are made by Hydro Ottawa based on previous recommendations.

    - Navigant will review the updated version of the DSP and provide additional comments and recommendations, if any.
    - Navigant will provide a letter for Hydro Ottawa to include within its rate application submission as to the completeness of the DSP with regards to the requirements outlined within the OEB's Chapter 5 Filing Requirements.

5. Act as expert witness during Hydro Ottawa's rate application procedure

    - Navigant will, as required, provide support in the form of expert witness testimony, responses to interrogatories, as Hydro Ottawa proceeds through the rate application process.

6. **Delivery Format**
    - Electronic (Word Document) copy of the revised documents with markups of suggested changes and comments.
    - Face to Face meeting after first review of DSP and supporting documents.

SCHEDULE B

Fee Schedule

DESCRIPTION OF SERVICES:	**Independent Assessment of Hydro Ottawa's Distribution System Plan**
CONSULTANT:	**Navigant Consulting Ltd.**
TOTAL PRICE (Canadian $):	**$85,000.00 /plus HST**

Payment Milestone Schedule:

50% of the total price as set out in Schedule B upon Hydro Ottawa's issuance of a Purchase Order number;

50% of the total price as set out in Schedule B upon completion of the Assessment to Hydro Ottawa's satisfaction.

HOURLY RATES for SCOPE ADDITIONS / DELETIONS	
POSITION	**2019 HOURLY RATES**
Managing Director	**$610.00**
Director	**$495.00**
Associate Director	**$430.00**
Managing Consultant	**$360.00**
Senior Consultant	**$315.00**
Consultant	**$245.00**

All fees listed above will be valid for the duration of the engagement, including post-filing support into 2020.

HYDRO OTTAWA EXPENSE POLICY

Hydro Ottawa's Expense Policy is attached as **Appendix 1** to this Schedule B and shall be applied in accordance with section 4.b) of the Agreement. Hydro Ottawa shall not be liable for any expenses that are not subject to the Hydro Ottawa Expense Policy and, if applicable, pre-approved by Hydro Ottawa.

APPENDIX 1 TO SCHEDULE B

Hydro Ottawa's Expense Policy

TRAVEL

1. The Consultant personnel and/or Subcontractor shall travel by the most practical and economical means possible.
2. When travelling by automobile or taxi, if feasible, The Consultant personnel and/or Subcontractor should travel together to reduce costs.
3. When available and practical, air travel should be booked in economy class.
4. Premium class rail travel is permissible providing it is less expensive than economy air travel.
5. The use of personal automobiles in lieu of rental vehicles or taxis is acceptable when it is more economical to do so.

   Note: Other than the mileage rate referenced below, Hydro Ottawa does not assume any financial and/or insurance responsibility when The Consultant personnel and/or Subcontractor use personal automobiles for business purposes.

6. The Consultant will be reimbursed for the business use of personal automobiles based on current Hydro Ottawa mileage rates which the Consultant shall confirm with Hydro Ottawa prior to a request for reimbursement
7. When renting automobiles for business travel, The Consultant and/or Subcontractor shall rent up to "mid-size" automobiles unless travelling in a group of 3 or more, when "full-size" rentals are permitted.

MEALS

1. The Consultant will be reimbursed for all reasonable meal expenses while travelling on Hydro Ottawa business.
2. Gratuities related to business dining are not to exceed 15%.
3. Individual bills should be obtained when travelling on business and dining with fellow Hydro Ottawa employees.
4. Room service and/or mini bar food items are not reimbursable.

ACCOMMODATION

1. Accommodation expenses will be reimbursed for standard guestrooms.

   Note: Room upgrades are permissible due to last minute/urgent travel when standard rooms are unavailable.

OTHER

1. Original receipts (with details on the date, description of item/service purchased, purchase amount and itemized taxes) must be kept and be made available upon request.

   Note: On an exception basis, a credit card summary can be used to replace a lost receipt.

2. Travel and/or accommodation cancellation charges for reasons outside the control of The Consultant are reimbursable.

EXCLUSIONS

Examples of items that are not reimbursable include:

1. fines/traffic violations
2. premium rates for luxury hotels and automobiles
3. alcohol
4. entertainment/hospitality

Note: *Emergency dry cleaning costs are reimbursable.*

Bay Adelaide Centre
333 Bay Street | Suite 1250
Toronto, ON M5H 2R2

+1.416.777.2440

navigant.com

March 10, 2019

Margaret Flores
Supervisor, Asset Planning
Hydro Ottawa Limited
3025 Albion Road North, PO Box 8700
Ottawa, ON K1G 3S4
margaretflores@hydroottawa.com

Re: Independent Assessment of Hydro Ottawa's Distribution System Plan

Dear Margaret,

Navigant Consulting Ltd. (Navigant) is pleased to offer this proposal to conduct an independent assessment of Hydro Ottawa Limited's (Hydro Ottawa) Distribution System Plan (DSP). We understand the expert review and assessment will be performed to support Hydro Ottawa's next planned rate application to the Ontario Energy Board (OEB) in December 2019.

Navigant recognizes that its independent review is intended to accomplish the following objectives:

- Advising whether Hydro Ottawa's DSP aligns with applicable OEB filing requirements;
- Assess how the DSP addresses the OEB's four performance outcomes, customer focus, operational effectiveness, public policy responsiveness, and financial performance;
- Produce a letter that provides a clear and well-documented assessment of our review and comments as to the completeness of the DSP with regards to the OEB's requirements; and,
- Provide regulatory support, if needed, to respond to interrogatories, attend technical conferences and appear before the OEB in oral hearings.

Navigant is uniquely positioned to deliver this support to Hydro Ottawa. Our team offers:

- Direct experience conducting independent reviews of Distribution System Plans in Ontario;
- Knowledge of Hydro Ottawa' distribution system;
- Knowledge of industry best practices of topics addressed in the DPS for electric utilities throughout North America; and,
- Direct experience developing evidentiary support for other rate proceedings and providing expert testimony before the OEB.

We are able to offer Hydro Ottawa competitive pricing to perform the services requested because we are familiar with Hydro Ottawa's DSP processes, its distribution system, and the OEB's requirements outlined in Chapter 5 Filing Requirements for Electricity Distribution Rate Applications.

We look forward to the opportunity to once again work with Hydro Ottawa and would be pleased to answer any questions you might have with respect to our proposal.

Sincerely,



Benjamin Grunfeld
Managing Director
benjamin.grunfeld@navigant.com

NAVIGANT

Proposal for

Independent Assessment of Hydro Ottawa's Distribution System Plan

Presented to

HydroOttawa

Submitted by

Navigant
Bay Adelaide Centre
333 Bay Street, Suite 1250
Toronto, ON M5H 2R2

+1.416.777.2440

www.navigant.com

March 10, 2019

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NAVIGANT

Independent Assessment of Hydro Ottawa's Distribution System Plan

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5.1 Pricing 8
5.2 Schedule 8

Appendix A. Project Team CV's A-1

1. Relevant Experience

1.1 Distribution Plan and Capital Program Reviews

Navigant has successfully completed many similar reviews and engagements, both within and outside of Ontario. Many of these reviews included an independent review of distribution and capital plans. Representative projects that Navigant has successfully completed are presented below.

Independent assessment of Toronto Hydro's Distribution System Plan and business cases
Toronto Hydro retained Navigant to conduct an independent review of its Distribution System Plan (DSP) prepared to support distribution projects and programs that Toronto Hydro submitted for approval under the Ontario Energy Board's Chapter 5 requirements for electricity transmission and distribution applications (EB-2014-0116). Navigant's review included a determination regarding the consistency of the DSP with the Ontario Energy Board Chapter 5 requirements, a detailed assessment of the DSP planning methodology and decision tools, and the application of Toronto Hydro's DSP framework to specific business cases. Navigant's proposed project lead for this engagement, Mr. Shlatz, appeared as an expert witness before the Ontario Energy Board in a recent rate filing to support its independent findings in Toronto Hydro's DSP before the Ontario Energy Board (EB-2014-0116).

Copeland TS business case development support
Toronto Hydro engaged Navigant to conduct a feasibility study and develop a business case in support of a $200 million distribution substation in the downtown Toronto business district. Navigant conducted a detailed assessment of project need based on technical and economic criteria, which determined a new substation located entirely underground was superior to other supply alternatives, including distributed resource and energy efficiency options. Among other reasons, Navigant determined the substation was required to serve growing loads and to provide critical back-up support to other downtown substations. Navigant's proposed project lead for this engagement, Mr. Shlatz, appeared as an expert witness before the Ontario Energy Board in a rate filing to support the substation, and the Ontario Energy Board subsequently approved the project (EB-2012-006).

Distributed generation enablement and Green Energy Act plan development
In a follow on to a prior distributed generation potential study for Toronto Hydro and the Ontario Power Authority, Navigant assessed the connection capacity of and enabling options for Distributed Generation across Toronto Hydro's entire distribution system. Toronto Hydro filed Navigant's report with the Ontario Energy Board as part of its Green Energy Act (GEA) Plan. Navigant also supported Toronto Hydro in developing its GEA Plan covering both renewable integration and smart grid initiatives.

Independent engineering review and evaluation of distribution capital projects
Navigant was retained to provide a third-party, independent engineering review and evaluation of distribution capital projects for ATCO's 2014 Performance Based Rate (PBR) filing before the Alberta Utilities Commission (AUC).

Independent review of Capital Investment Plan, electric tariff filing
Navigant was retained by Green Mountain Power (Vermont, USA) to conduct an independent review of all capital projects submitted to the Vermont Public Utility Commission (VPUC) in a 2017 tariff filing (Docket No. 17-3112-INV). Mr. Gene Shlatz, who Navigant proposes to assign as an independent expert for the CIR, submitted prefiled testimony and appeared as an expert witness before the VPUC. The VPUC issued as favorable Order on behalf of Green Mountain, approving the large majority of capital projects where the company requested recovery in retail rates.

Capital development planning
Navigant was engaged to prepare a 20-year capital development plan on behalf of Saskatoon Light & Power. The objective of our analysis was to create a long-term plan designed to meet reliability and performance objectives at lowest cost. Our assessment included a review and analysis of T&D engineering, maintenance and operations; including recommendations for improvement. Mr. Gene Shlatz, who Navigant proposes to assign as an independent expert for the CIR, was responsible for development of the plan, including a detailed engineering review of candidate transmission and distribution enhancements and the selection of the preferred long-term plan.

Asset Management program implementation and rate case support
Navigant was engaged by Horizon Utilities Corporation (HUC) to develop strategies and assist in the implementation of an asset management project. Navigant also provided ongoing support for HU's asset management initiative. It included an evaluation of infrastructure upgrades, operational and reliability improvement and implementation strategies using AM-based approaches. Mr. Gene Shlatz, who Navigant proposes to assign as an independent expert for the CIR, led this engagement and provided expert support on behalf of HUC in subsequent rate filings before the OEB.

Power flow, transient stability, and reactive power compensation studies
Navigant supervised detailed power flow, transient stability, and reactive power compensation studies for two 500 kV HVDC projects to be built in Alberta. Reviewed work of another consultant on the data, criteria, modeling, methodology, and assumptions used for studying the two HVDC projects. Navigant prepared a detailed report describing its review of the other consultant's study work and Navigant's study results.

1.2 Experience with the Ontario Energy Board

Navigant's focus on the Ontario energy sector is clearly evident in the substantial amount of work that has been submitted to the OEB as evidence and, in many cases, defended in testimony. Table 1, below provides a summary of some of recent engagements over the past five years.

Table 1: Select Recent Experience Submitting Evidence to the OEB

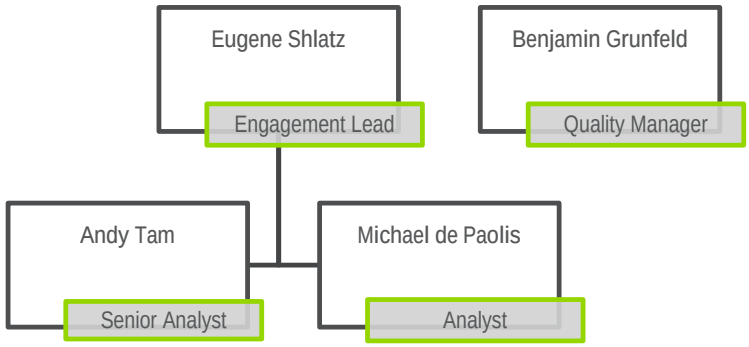
Client	Report Title	Date	Proceeding	Testimony Required
Hydro One Networks	Working Capital Requirements of Hydro One Networks Distribution Business	2016-12-19	EB-2017-0049	TBD
Hydro One Networks	Distribution Unit Cost Benchmarking Study: Pole Replacement and Substation Refurbishment	2016-10-19	EB-2017-0049	TBD
London Hydro	Working Capital Requirements of London Hydro's Electricity Distribution Business	2016-07-12	EB-2016-0091	No
Hydro One Networks	Total Transmission Cost Benchmarking	2016-05-17	EB-2016-0160	Yes
Hydro One Networks	Working Capital Requirements of Hydro One Networks Transmission Business	2016-05-06	EB-2016-0160	No
Five Nations Energy Inc.	Working Capital Requirements of Five Nations Energy Inc.	2016-04-25	EB-2016-0231	No

Entegrus Powerlines Inc.	Determination of Working Capital Requirements	2015-12-11	EB-2015-0061	No
Hydro Ottawa	Working Capital Requirements of Hydro Ottawa's Electricity Distribution Business	2015-10-20	EB-2015-0004	No
Kingston Hydro	Working Capital Requirements of Kingston Hydro's Electricity Distribution Business	2015-09-29	EB-2015-0083	No
North Bay Hydro	Working Capital Requirements of North Bay Hydro Distribution Ltd.'s Distribution Business	2015-07-27	EB-2014-0099	No
Toronto Hydro-Electric System Limited	Independent Assessment of Toronto Hydro's Distribution System Plan and Business Cases	2014-07-29	EB-2014-0116	Yes
Toronto Hydro-Electric System Limited	Working Capital Requirements of Toronto Hydro Electric System Limited's Distribution Business	2014-06-27	EB-2014-0116	No
Horizon Utilities	A Determination of the Working Capital Requirements of Horizon Utilities' Distribution Business	2014-03-31	EB-2014-0002	No
Hydro One Networks	Distribution Line Loss Study	2014-01-28	EB-2013-0416	No
Hydro One Networks Inc. (distribution)	Working Capital Requirements of Hydro One Networks' Distribution Business	2013-12-03	EB-2013-0416	No
Toronto Hydro-Electric System Limited	Incremental Capital Module – Evidentiary Support (Ongoing technical studies and appearances before the OEB)	2012 - 2014	EB-2012-0064	Yes
Hydro One Networks Inc. (transmission)	A Determination of the Working Capital Requirements of Hydro One Networks' Transmission Business	2012-03-27	EB-2012-0031	No
Hydro One Networks	Customer Density and Distribution Service Costs	2011-11-11	EB-2012-0136	Yes
Hydro One Networks	Customer Density and Distribution Service Costs	2011-11-11	EB-2012-0136	Yes

2. Team Qualifications and Experience

Navigant is very qualified to perform the work. We have conducted many engagements on behalf of Hydro Ottawa and other Ontario distribution companies, many of which required our staff to submit evidence or appear before the Ontario Energy Board as expert witnesses. Navigant proposes to assign key team members that supported independent reviews and appeared as an expert witness before the OEB in prior filings related to DSPs.

Figure 1: Project Team Overview



The biographies of consultants that Navigant proposes to assign to this engagement are as follows:

Eugene (Gene) Shlatz is a Director in the global Energy practice at Navigant. He will serve as the Engagement Lead and the Expert Witness (as applicable) for this engagement. He has over 30 years of experience in electric utility engineering, operations and technology assessment. He is an expert on electric power delivery system, and has been responsible for electric asset management, reliability, distributed energy, benchmarking, and system adequacy reviews for US, Canadian, and South American utilities. Mr. Shlatz has worked on several related engagements over the past 10 years, including an independent review of Toronto Hydro's DSP filed before the OEB in 2014. He holds graduate and undergraduate degrees in Electric Power Engineering from Rensselaer Polytechnic Institute and is a registered professional engineer. He also is prequalified as an expert in Ontario resulting from prior appearances before the OEB. Gene also has appeared as an expert witness or provided testimony in over two dozen regulatory filings in the U.S. and Canada.

Benjamin Grunfeld is a Managing Director in Navigant's Global Energy Practice and the Canadian Power and Utilities Sector Leader. He will serve as the Technical Quality Manager for this engagement. He is a trusted advisor to electricity and natural gas utilities, independent power companies, regulators, and governments. He has considerable experience in the areas of regulatory economics, power project

development and finance, power procurement, electricity market design and operations, energy policy, strategy and operations, and mergers and acquisitions. Benjamin has worked in vertically integrated and restructured markets across Canada and North America, as well as a range of developed and emerging economies around the world. He has successfully led the execution of regulatory studies for utilities in front of the Ontario Energy Board to further regulatory strategies or comply with regulatory requirements and has defended those studies during oral hearings. He is a recognized expert on the energy sector in Canada and has served as an expert witness in regulatory and civil matters.

Andy Tam is an Associate Director in Navigant's global Energy practice. Andy will support the review and analysis under Gene's direction. His experience spans projects with electric regulators, major generation, transmission, and distribution utilities, and various other energy related public/private sector entities. Mr. Tam previously reviewed Toronto Hydro's 2015-2019 DSP. Andy have worked on technical and financial evaluations of smart grid/micro grid technologies, due diligence for utility M&A, and regulatory cost of service/revenue requirement support for natural gas utilities. Mr. Tam has also completed financial working capital evaluations for three of the largest utilities in Ontario. Prior to joining Navigant, Mr. Tam worked at Hydro One Networks Inc. as a financial analyst, completing a two-year leadership rotation program where he worked on utility financial modelling, business planning, regulatory analysis and business process optimization. Mr. Tam received his Master of Business Administration (MBA) from the Ivey School of Business in London, Ontario, Canada and both his Bachelor of Science in Computer Engineering (Honours), and Bachelor of Arts in Economics degrees from Queen's University in Kingston, Ontario, Canada.

Michael de Paolis is a Senior Consultant in Navigant's global Energy practice. Juan will support the review and analysis under Gene's direction. His areas of expertise are distribution modelling, performance assess and risk-based asset management. Michael has worked in many areas of the energy sector, with depth in renewables integration, distribution system evaluation and cost of service assessments for electric utilities. Michael received a B.ASc in Engineering Science, majoring in Energy Systems, from the University of Toronto.

3. Proposed Approach and Methodology

Navigant will provide professional services for the independent review of Hydro Ottawa's DSP and associated business cases. We expect the DSP and associated business cases will include asset renewal, capacity expansion and system upgrades that Hydro Ottawa expects to place into service over the five-year rate period.

Navigant will review and evaluate Hydro Ottawa's DSP and engage, as needed, with Hydro Ottawa's subject matter experts, with the objective of advising on the following:

1. Is Hydro Ottawa's DSP consistent with the guidelines and objectives set forth in Chapter 5 of the OEB's Filing Requirements for Electricity Distribution Rate Applications?
2. How well the DSP addresses the OEB's four performance outcomes, customer focus, operational effectiveness, public policy responsiveness, and financial performance?

The proposed scope of work for this engagement includes five main deliverables.

1. Review Hydro Ottawa's draft DSP and provide markups with suggested changes and comments

    - Navigant will review Hydro Ottawa's draft DSP and supporting documentation (including the company's overarching strategic asset management plan) and recommend changes/provide comments regarding compatibility of its contents with OEB Chapter 5 Filing Requirements and highlight areas that may garner additional inquiries from the OEB or interveners.
    - Navigant will provide comments and recommendations regarding the contents, language and formatting of the draft DSP.

2. Summary of the action items following a face-to-face meeting in Ottawa with Hydro Ottawa Staff

    - Navigant will meet with Hydro Ottawa staff, in Ottawa, to go over recommendations and comments.
    - Provide direction as to how the recommendations should be incorporated in the next version of the DSP with regards to prioritization of gaps or suggestions.

3. Review Hydro Ottawa's program-level (23) and project-level (~20) business cases and individual asset category asset management plans (13) that support the investment outlined in the DSP and provide markups and suggested changes and comments

4. Provide written recommendation following a second review, once changes to the original draft are made by Hydro Ottawa based on previous recommendations.

    - Navigant will review the updated version of the DSP and provide additional comments and recommendations, if any.
    - Navigant will provide a letter for Hydro Ottawa to include within its rate application submission as to the completeness of the DSP with regards to the requirements outlined within the OEB's Chapter 5 Filing Requirements.

5. Act as expert witness during Hydro Ottawa's rate application procedure

    - Navigant will, as required, provide support in the form of expert witness testimony, responses to interrogatories, as Hydro Ottawa proceeds through the rate application process.

4. References

Contact Name:	Amanda Klein	**Phone Number:**	+1 (416) 542-2729
Company:	Toronto Hydro	**Title:**	EVP, Regulatory Affairs and General Counsel

Project Description:

Independent assessment of Toronto Hydro's Distribution System Plan and business cases

Toronto Hydro retained Navigant to conduct an independent review of its Distribution System Plan (DSP) prepared to support distribution projects and programs that Toronto Hydro submitted for approval under the Ontario Energy Board's Chapter 5 requirements for electricity transmission and distribution applications (EB-2014-0116). Navigant's review included a determination regarding the consistency of the DSP with the Ontario Energy Board Chapter 5 requirements, a detailed assessment of the DSP planning methodology and decision tools, and the application of Toronto Hydro's DSP framework to specific business cases.

Contact Name:	Barry Goy	**Phone Number:**	+1 (780) 420-3987
Company:	ATCO Electric	**Title:**	SVP, Strategic Initiatives

Project Description:

Independent engineering review and evaluation of distribution capital projects

Navigant was retained to provide a third-party, independent engineering review and evaluation of distribution capital projects for ATCO's 2014 Performance Based Rate (PBR) filing before the Alberta Utilities Commission (AUC).

Contact Name:	Charlotte Ancel	**Phone Number:**	+1 (802)-655-8764
Company:	Green Mountain Power	**Title:**	General Counsel

Project Description:

Independent review of Capital Investment Plan, electric tariff filing

Navigant was retained by Green Mountain Power (Vermont, USA) to conduct an independent review of all capital projects submitted to the Vermont Public Utility Commission (VPUC) in a 2017 tariff filing (Docket No. 17-3112-INV). Mr. Gene Shlatz, who Navigant proposes to assign as an independent expert for the CIR, submitted pre-filed testimony and appeared as an expert witness before the VPUC. The VPUC issued as favorable Order on behalf of Green Mountain, approving the large majority of capital projects where the company requested recovery in retail rates.

5. Pricing and Schedule

This section of the proposal includes Navigant's price offer, as well as the schedule for the engagement.

5.1 Pricing

Navigant's proposed fees for the first four deliverables is **$85,000**, plus HST and customary travel expenses. Navigant's proposed fees assume that we will be reviewing full and complete documents, and that the process not be iterative where incomplete documents are provided and updated throughout and as a result sections need to be re-reviewed. We understand that documents will be provided in draft, but we expect that the documents will be complete drafts.

Preparing interrogatory responses, pre-filed testimony, and testifying as an expert witness before the OEB will be on a time and materials basis, as needed.

Navigant's fee schedule for consulting services is presented in Table 2

Table 2. Professional Fee Rate Schedule

Level	Standard Hourly Bill Rate (CAD)
Managing Director	$610
Director	$495
Associate Director	$430
Managing Consultant	$360
Senior Consultant	$315
Consultant	$245

All fees listed above will be valid for the during of the engagement, including post-filing support into 2020.

5.2 Schedule

Navigant is aware that the term of the engagement will depend upon the OEB's procedural timelines for the planned application.

We expect the majority of our work will be completed by the end of July 2019, with the major milestone dates as outlines below:

- Copy of Draft DSP provided to Navigant – March 29, 2019
- Navigant review of Draft DSP complete – April 19, 2019
- Face-to-face meeting – week of April 22, 2019
- Revised DSP provided to Navigant – May 31, 2019
- Navigant review of Revised DSP complete – June 14, 2019
- Program- and project-level business cases provided to Navigant – June 14, 2019
- Navigant's review letter provided to Hydro Ottawa – June 28, 2019
- Navigant review of business cases complete – July 12, 2019

Appendix A. Project Team CV's

Resumes for our proposed project team follow and appear in the following order:

- Eugene Shlatz, Director
- Benjamin Grunfeld, Managing Director
- Andy Tam, Managing Consultant
- Michael De Paolis, Senior Consultant

eshlatz@navigant.com
Burlington, VT
Direct: 802.233.1890

Professional Summary

Gene has over 30 years of management consulting and supervisory experience in energy delivery, electric power generation and distributed energy systems. Engagements he has directed include smart grid, renewable technology, microgrids, asset management, electric pricing, due diligence and system adequacy studies. His clients include US, Canadian, European and South American utilities, suppliers and government agencies. Gene is an expert on electric power delivery systems, and has testified before FERC and state regulatory commissions on open access, transmission, DG integration, retail rates, regulatory compliance, and least-cost planning. He has numerous published articles on smart grid, distributed resources, electric reliability, asset management, energy efficiency, and electric pricing.

Professional Experience

Directs project teams and manages consulting engagements for electric utility, government and energy supply clients. Responsible for energy delivery and power production assignments in the following areas:

- **Emerging Technologies** – renewable technology and smart grid integration, energy efficiency and technical/economic assessment of distributed resources
- **Asset Management** – implementation strategy, project prioritization, performance measurement, utilization and cost optimization, electric delivery system planning
- **Operations & Planning** – transmission and distribution performance evaluation; target setting, remediation analysis, service quality standards and business process improvement
- **Regulatory** – capital planning, marginal and locational-based costs, expert witness support

Representative Client List and Engagements

Distributed Generation, Microgrids & Advanced Technologies

- California Energy Commission/Southern California Edison. Project manager of DER integration studies for a major utility planning region. Predicted hosting capacity limits and options to increase DER capacity and value via advanced communications and control technologies. Assessed the capability of energy storage to increase capacity limits.
- U.S. Department of Energy/Dominion Virginia Power. Project manager of Solar Integration Study to identify renewable capacity impacts and integration requirements in the state of Virginia. Determined distribution hosting capacity limits and impacts of increasing amounts of solar on DVP's generation, transmission and distribution system.
- Los Angeles Department of Water & Power. Technical lead of a DER integration study to determine integration requirements and hosting capacity limits, and approaches to target DER based on locational needs and benefits. Assessed communication and control strategies, organization structure, tariff and rate options and preferred strategy to achieve renewable portfolio targets.
- Orange & Rockland Utilities. Project manager of a DG Interconnection benchmarking analysis. Conducting studies to predict hosting capacity limits on O&R's T&D system and mitigation options in support of NY's Renewable Energy Vision initiative.

- Pacific Gas & Electric Company. Project manager of a Transmission and Distribution PV Impact Study. It included engineering analyses designed to facilitate the integration of DGPV into the grid. Developed PV values based on analysis across multiple scenarios and attributable to DGPV.
- Major Southeastern U.S. Utility (Confidential). Project manager of a Solar Integration Study to assess the technical and economic impact of increasing amounts of solar on the utilities' generation, transmission and distribution system.
- California Energy Commission/Southern California Edison. Project manager of a study evaluating DG impacts and integration requirements for up to 12,000 MW of DG in California by 2020. Developed a technical evaluation and costing framework applicable to all CA utilities.
- U.S. Navy. Evaluated on-site microgrid options for a major military shipyard, including technical assessment of renewable generation, control strategies, electric system performance and system upgrades required to operate in stand-alone and parallel modes of operation.
- U.S. Department of Energy (DOE). Provided technical and program management support for DOE's Smart Grid Investment Grant (SGIG) program. Responsible for impact evaluation of smart grid technologies, including program benefits and implementation strategies.
- PowerStream (Ontario). Providing project management and evaluation services for an on-site microgrid comprised of a mix of wind, solar, storage and gas-fired technologies. Developing control and dispatch strategies and methods for assessing MG performance and benefits.
- NV Energy. Project manager of DG and large PV integration studies for southern and northern Nevada. Identified technical/capacity limits of renewable energy sources on NV Energy's T&D system. Responsible for technical and economic evaluation of power system impacts and integration costs, including intermittency. Testified before Nevada Commission to support findings.
- Toronto Hydro. Project manager of comprehensive evaluation of distributed energy resources versus traditional T&D alternatives for a major urban center. Included a technical assessment of DG systems impacts, technology integration and forecast of cost-effective alternatives.
- Southern California Edison Company. Technical support a 3-year integrated grid pilot designed to demonstrate modern grid infrastructure functionality and advance customers' ability to interconnect renewable energy sources, proactively manage customer demand, and improve the safety and reliability of the grid in a cost-effective manner. The project deployed advanced technologies to facilitate the integration of high penetration distributed energy resources (DER).

Reliability, Benchmarking and Electric System Planning

- Hawaiian Electric Company. Project manager of a technical analysis to assess the impact of capital and O&M improvement programs on electric system reliability performance during storms and major events. Demonstrated a correlation of program improvements and system resiliency during storms.
- Exelon/Commonwealth Edison. Lead consultant of an engineering and operational assessment of Exelon's system design, construction and maintenance practices. Our study was filed before the ICC in response to claims of system inadequacy for major storms. Provided expert witness testimony that confirmed ComEd's T&D practices were consistent with or exceeded industry standards.

- Jersey Central Power & Light. Principle investigator of a commission-mandated Operations Review of JCP&L's distribution system. The review included an assessment of reliability, storm response, preventative maintenance and budgeting processes. Navigant's report and recommendations were unanimously approved and accepted by the New Jersey Board of Public Utilities.
- Exelon/Commonwealth Edison. Lead consultant of an engineering and operational assessment of Exelon's system design, construction and maintenance practices. Our study was filed before the ICC in response to claims of system inadequacy for major storms. Provided expert witness testimony that confirmed ComEd's T&D practices were consistent with or exceeded industry standards.
- Saskatoon Light & Power. Project manager of a 20-year capital development plan designed to meet reliability and performance objectives at lowest cost. Our assessment included a review and analysis of T&D engineering, maintenance and operations; including recommendations for improvement.
- Sulphur Springs Valley Electric Cooperative (SSVEC). Project manager of an independent Feasibility Study of delivery alternatives, including T&D, distributed generation, energy efficiency, energy storage and renewables. Successfully testified as an expert witness before AZ commission.
- Austin Energy. Performed a benchmarking and gap analysis of AE's engineering and operations. Prepared recommendations to enhance reliability and operations efficiency.
- Saskatoon Light & Power. Project manager of a 20-year capital development plan designed to meet reliability and performance objectives at lowest cost. Our assessment included a review and analysis of T&D engineering, maintenance and operations; including recommendations for improvement.
- Toronto Hydro Electric System, Limited (THESL). Performed a long-range planning study for THESL's radial and network downtown distribution system. Evaluated capital expansion versus CDM needed to serve downtown Toronto for 20 years.
- Sulphur Springs Valley Electric Cooperative (SSVEC). Project manager of an independent Feasibility Study of delivery alternatives, including T&D, distributed generation, energy efficiency, energy storage and renewables. Successfully testified as an expert witness before AZ commission.
- Austin Energy. Performed a benchmarking and gap analysis of engineering and operations performance for AE's energy delivery organization.
- Ameren Services. Conducted a review and predictive assessment of distribution reliability. A methodology was developed to apply fact-based methods to allocate reliability expenditures.
- American Electric Power. Conducted a review and predictive assessment of distribution reliability. Applied fact-based methods to prioritize investment decisions and to quantify risk.
- Potomac Electric Power Company (PHI). Conducted an investigation and benchmarking of PEPCO's T&D system, including transmission and distribution infrastructure. Prepared recommendations to enhance performance and reduce outage risk.
- National Grid. Conducted a system review and predictive assessment of distribution reliability. A strategic methodology was developed to predict system outage performance based on system attributes, equipment performance and historical reliability.
- Potomac Electric Power Company (PHI). Project manager of a benchmarking analysis of PEPCO's T&D system, including transmission and distribution infrastructure. Prepared recommendations to enhance performance and reduce outage risk.

- Dominion – Virginia Power. Project manager and lead investigator of a comprehensive technical review and risk assessment of secondary networks. Reviewed and analyzed engineering standards, planning criteria, operations and maintenance, and construction methods.

Asset Management

- Horizon Utilities Corporation. Developed strategies and provided ongoing support for HU's asset management initiative. Conducted a gap analysis and implementation of asset management strategies and evaluation methods. Included an evaluation of infrastructure upgrades, operational and reliability improvement and implementation strategies using AM-based approaches.
- First Energy. Lead consultant of a project team that implemented asset management processes and capital prioritization models for 6 operating companies in three jurisdictions. Responsible for model development and applications, technical review and overall quality assurance.
- Seattle City Light. Conducted a benchmarking and gap analysis of the power supply and energy delivery business units. It included a business case analysis to support implementation of asset management methods and new AM organization.
- Pepco/Conectiv (PHI). Responsible for an asset management and prioritization assessment of capital improvement and O&M programs for three states and the District of Columbia. It included developing asset prioritization methods for transmission, distribution and IT programs.
- Entergy. Responsible for an asset management and prioritization assessment of Entergy's capital improvement programs for six jurisdictional utilities in 5 states. It included developing asset-specific prioritization methods for transmission and distribution programs.
- PacifiCorp. Responsible for an asset management and prioritization assessment of PacifiCorp's capital improvement programs for six jurisdictional utilities in 6 states. It included developing asset-specific prioritization methods for transmission and distribution and IT programs.

Regulatory and Pricing

- NV Energy (Sierra Pacific Power Company). Conducted a T&D avoided cost study to support an SPPC's rate filing and to determine Excess Energy Charges for net metering customers. Submitted expert testimony before the Nevada Commission on T&D marginal costs and application to NEM solar.
- Exelon (Philadelphia Electric Company). Developed T&D avoided cost study to support PECO energy efficiency programs. Participated in a statewide stakeholder process to approve T&D avoided costs, which included the statewide EE program evaluator, the electric utility and related parties.
- Puerto Rico Electric Power Authority (PREPA). Conducted a T&D avoided cost analysis and prepared expert testimony to support PREPA's rate filing and avoided costs applied to net metered customers.
- Public Utility Authority (Israel). Conducted a technical and economic review of the Israeli Electric Corporation and Palestinian Electric Authority electric generation and power delivery system on behalf of the PUA. The review focused on the adequacy of IEC and PA electric infrastructure, power costs and investment programs.
- Vermont Department of Public Service (VDPS). Conducted a geo-targeted analysis of energy efficiency programs designed to defer T&D investments. Worked with electric utility stakeholders to identify cost-effective deferral opportunities and to assess processes designed to target EE programs.

- Toronto Hydro Electric System, Limited (THESL). Prepared business case studies for major capital programs in a rate filing before the Ontario Energy Board. Testified as an expert witness on several critical T&D infrastructure programs, the majority of which were approved by the board.
- Canadian Utility (Confidential) – Confidential study to assess the value and strategic benefits of the acquisition of electric utility energy delivery assets. Included a technical and economic assessment of key regulatory and acquisition risk factors to support a recommendation.
- Progress Energy. Project manager of a best practices and compliance review of fixed asset charging practices. Reviewed methods, systems and practices used to record fixed assets for Florida and the Carolinas to support proposed changes filed with state commissions and the SEC.
- Citizens Utilities/Vermont Electric Cooperative. Supported numerous Certificate of Public Good (CPG) applications before the Vermont Public Service Board (VPSB). Expert witness for technical, environmental, and costing studies.
- Vermont Department of Public Service (VDPS). Conducted research and prepared sections of the Twenty-Year Electric Plan, including the impact of the independent system operator (ISO) and regional transmission organization (RTO) initiatives on Vermont's transmission providers.
- Potomac Electric Power Company (PHI). Project manager of a benchmarking study of storm hardening measures. Assessed the impact of hardening options on reliability and performance. Also assessed service quality (SQI) measures and performance-based rate (PBR) mechanisms.
- Citizens Utilities (Vermont Electric Division). Project manager for a T&D Audit mandated by the Vermont Public Service Board. Reviewed T&D plant accounting systems and processes, and provided recommendations for improvement.
- Massachusetts Department of Telecommunications and Energy (MDTE). Project manager of a stray voltage assessment of jurisdictional utilities. Identified causes of stray voltage and provided recommendations to mitigate future events, including action and improvement plans.

Work History

Navigant Consulting, Director
Stone & Webster Management Consultants, Executive Consultant
Green Mountain Power Corp, Assistant Vice President, Energy Planning
Ernst & Whinney, Supervisor
Gilbert/Commonwealth, Senior Consulting Engineer
Westinghouse Electric Corporation, Systems Analysis Engineer
Boston Edison Company, Student Engineer, Cooperative Education Prog.

Certifications, Memberships, and Awards

Professional Engineer - State of Vermont
Institute of Electrical and Electronic Engineers, Section Chairman (Past)

Education

M.S. Electric Power Engineering, Rensselaer Polytechnic Institute
B.S. Electric Power Engineering, Rensselaer Polytechnic Institute

Articles & Publications

- "Smart Grid and Distributed Energy Storage," Total Energy USA, Houston Texas, November 2012.
- "Distributed Generation: Grid Impacts and Interconnection Strategies," Rocky Mountain Electric League, 2012 Spring Management, Engineering and Operations Conference, Omaha Nebraska.
- "Energy Storage Opportunities for Integration of Large-Scale Renewable Generation," Electricity Storage Association (ESA) Annual Conference, Washington DC, May 2012.
- "Grid Integration of Renewable, Intermittent Resources," 2011 PowerGen International Conference, December 2011, Las Vegas, NV, with Vladimir Chadliev.
- "Reducing T&D Investments Through Energy Efficiency" IEPEC, August 2011, with Kathryn Parlin & Walter Poor.
- "Value of Distributed Generation and Smart Grid Applications," DistribuTECH, San Diego, February, 2011.
- "Prioritization Methods for Smart Grid Investments," EEI Perspectives, April-May, 2010.
- "Evaluation of Targeted Demand-Side Management at ConEd (CECONY)," ACEEE Energy Efficiency Conference, September, 2009, with Craig McDonald.
- "DER Operational & Grid Benefits" Electric Light & Power, February, 2009.
- "Benefits of Smart Grid Integration with Distributed Energy Storage Systems," Infocast Power Storage Conference, July, 2008.
- "The Rise of Distributed Energy Resources," Public Utilities Fortnightly, Feb, 2007, with S. Tobias.
- "Risk Planning & Project Prioritization: Bringing Energy Delivery to the Next Level in Asset Management," InfoCast T&D Asset Management Conference, St. Louis, MI, May 2004.
- "Valuation Methods: Estimating the Value of Avoiding the Risks Associated with T&D Reliability Failures," EEI Spring 2004 T&D Conference, Charlotte, NC, April 2004.
- "Reliability Tradeoffs," EEI Perspectives, January-February, 2004, with Daniel O'Neill.
- "What's the Outlook for Distributed Generation Interconnection Standards?" 2003 PowerGen International Conference, Las Vegas, Nevada, December 2003.
- "Federal Interconnection Standards: Putting DG in a Box," Public Utilities Fortnightly, April 2003, with Stan Blazewicz.
- "An Innovative Approach to Fact-Based Distribution Reliability Cost Optimization," Distribution 2000, Brisbane, Australia, November 1999, with Cheryl Warren.
- "System Reliability: Competitive Issues," Rethinking Electric Reliability Conference, Chicago Illinois, September 1997.
- "Reliability: Competition & Keeping the Lights On," EUCI, Denver, Colorado, October 1998.
- "System Reliability in a Restructured Environment," Electric System Reliability in a Competitive Environment Workshop, Denver, Colorado, October 1997.

- "Privatization Efforts in South America" EUCI Workshop, Denver, Colorado, January 1997.
- "Open Access Pricing Issues," Transmission Pricing Conference, Vail, Colorodo, Sept. 1996.

Testimony and Appearance as an Expert Witness

Rate Cases, Integrated Resource Planning and Regulatory Investigations

Transfer of Electric Assets (Municipalization)	IBM	2017	15A-0589E	Colorado
Marginal Costs (NEM & Rate Filing)	NV Energy	2016	16-06006	Nevada
Custom Incentive Rate Filing	Toronto Hydro	2016	EB -2014-0116	Ontario
Incremental Capital Module (Rate Filing)	Toronto Hydro	2014	EB-2012-0064	Ontario
Summer/Winter 2011 Storm Review	Exelon/ComEd	2013	11-0588	Illinois
Distributed Generation Integration	NV Energy	2012	10-04008	Nevada
Distributed Utility Planning	CUC	2011	6290	Vermont
Power Purchase Contracts – IURC Complaint	Jay REMC	2003	9704-CP-069	Indiana
Section 205 Filing – Wholesale Rates	NISource	1998	ER96-35-000	FERC
Open Access Transmission Tariff Filing	NISource	1997	ER96-399-000	FERC
Request for Increase in Wholesale Rates	NISource	1996	ER92-330-000	FERC
Request for Increase in Retail Rates	GMP	1996	5532	Vermont
Least-Cost Planning Integrated Resource Plan	GMP	1991	5270	Vermont
Request for Increase in Retail Rates	GMP	1991	5428	Vermont
Request for Increase in Retail Rates	GMP	1990	5370	Vermont
Request for Increase in Retail Rates	GMP	1989	5282	Vermont
Request for Increase in Retail Rates	GMP	1988	5125	Vermont

Certificates of Public Good

Transmission Line Construction Authorization	SSVEC	2010	E-01575A	Arizona
Northern Loop Transmission Upgrades	Velco/CUC	2004	6792	Vermont
Substation Reconstruction – Richford	CUC	2003	6682	Vermont
Island Pond to Bloomfield Line	CUC	2001	6044	Vermont
HK Webster Substation	CUC	1999	6045	Vermont
Burton Hill Substation	CUC	1999	6046	Vermont
Border to Richford 120/46kV Line	CUC	1998	5331A	Vermont
New Transmission Lines and Substation	IBM	1991	5549	Vermont
New Substation – Northern Vermont	GMP	1990	5459	Vermont
Gas Turbine Interconnection Facilities	IBM	1989	5347	Vermont
Dover Substation Expansion	GMP	1987	5226	Vermont

Industry Restructuring & Asset Transactions

Purchase of Electric Assets	VEC	2004	6853	Vermont
Certificate of Consent, Sale of Distribution Assets	CUC	2004	6850	Vermont
Certificate of Consent, Sale of Transmission Assets	Velco/CUC	2004	6825	Vermont
Prudency Review and Audit Support	CUC	2003	5841/5859	Vermont
Competitive Opportunities Filing	ConEdison	1997	96-E-0897	New York

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Professional Summary

Benjamin Grunfeld is a Managing Director in the global Energy practice at Navigant, and the Canadian Power and Utilities Sector Leader. He is a trusted advisor to electricity and natural gas utilities, independent power companies, regulators, and governments. He has considerable experience in the areas of power project development and finance, power procurement, regulatory economics, electricity market design and operations, energy policy, strategy and operations, and mergers and acquisitions. Benjamin has worked in vertically integrated and restructured markets across Canada and North America, as well as a range of developed and emerging economies around the world.

Areas of Expertise

- **Strategy**: Guides senior executives and boards to develop and implement long term strategies and strategic initiatives.
- **Operations**: Supports senior operations executives to identify fact-based opportunities for performance improvement.
- **Policy**: Advices senior policy makers on effective electricity and natural gas policy development.
- **Markets**: Analyses the performance of energy markets, advices on effective market design, and supports market entry and investment decisions.
- **Regulation**: Provides guidance to utilities and regulatory agencies on the development of efficient regulatory policies and successful regulatory strategies.

Sample Professional Experience

- **Alternative rate design for transmission.** Director-in-charge and lead expert providing a review of alternative transmission rate designs for a large transmission and distribution electric utility. The Navigant team provided an analysis of alternative rate design options and models for revenue decoupling. [Client: Confidential (Utility); Date: 2018; Location: ON, Canada]
- **Value of grid services.** Director-in-charge and lead expert providing an overview of the value of transmission and distribution grid services. [Client: Confidential (Utility); Date: 2018; Location: AB, Canada]
- **Marginal emission factors.** Benjamin was the Director-in-charge responsible for a Navigant team developing and recommending a methodology to establish default emission factors for electricity imports under Ontario's proposed Cap and Trade legislation. The framework established the default emission factors based on a forecast of the emissions intensity of marginal generation resources in neighbouring jurisdictions. [Client: Ontario Ministry of Energy; Date: 2016; Location: ON, Canada]
- **Future of microgrids in Ontario.** Benjamin was the Director-in-charge of a Navigant team examining the relevance and economic viability of four microgrid use cases, forecasting if/when they can be economically deployed under current and projected rate structures. As part of the engagement Navigant facilitated a workshop with industry stakeholders. [Client: MaRS Advanced Energy Centre; Date 2016; Location: ON, Canada]

- **Microgrid and virtual power plant business model development.** Benjamin was the Director-in-charge of a Navigant team evaluating the North American market for microgrids and virtual power plants and advising on the development of a business model for a utility partnership with an equipment manufacturer. The Navigant team characterised the market in North America, conducted a competitor's assessment, identified the strategic and competitive advantage of the proposed partnership; and developed a recommended business model. [Client: Confidential (Utility); Date 2016; Location: North America]
- **Competitive bid development support for distribution connected storage project**. Benjamin was the Director-in-charge of a Navigant team that supported the development of a bids into two Independent Electricity System Operator's energy storage procurements. The Navigant team provided (i) financial modelling of the distribution-connected energy storage projects, (ii) conceptual dispatch modelling for provision of regulation, capacity, and load shifting services, (iii) a review of costs and challenges associated with provision of ancillary services and (iv) an assessment of alternative technologies [Client: Confidential (Multiple Utilities); Date 2016; Location: ON, Canada]
- **Solar / storage microgrid project development and funding application support**. Director-in-charge of the Navigant team that supported a successful applicant in Ontario's Smart Grid Fund for a microgrid incorporating renewable generation and energy storage. The proposal highlighted the operational flexibility of the microgrid for the customers served and the system benefits that would accrue. The client is developing this project with ongoing technical and financial support from Navigant. [Client: Confidential (Utility); Date 2015; Location: ON, Canada]
- **Residential solar / storage market assessment and program development**. Director-in-charge of the Navigant team supporting a utility in the development of a solar + storage program for residential customers. A key component of our analysis is optimizing the allocation of the power and energy capacity of the battery between the customer and the utility. Power and energy capacity allocated to the utility can be used to earn market revenue from various sources and reduce the customer costs for the solar / storage facility. [Client: Confidential (Utility); Date 2015; Location: ON, Canada]
- **Grid parity analysis for residential and small commercial solar + storage**. Director-in-charge of a Navigant team that conducted an analysis of the potential for residential and small commercial behind the meter solar + storage to achieve grid parity in Ontario over a 25-year time horizon. [Client: Confidential (Utility); Date 2014; Location: ON, Canada]
- **Distribution line loss study and allocation methodology.** Benjamin was the project manager and testifying expert for Navigant's comprehensive assessment of the technical and non-technical losses over Hydro One Network's distribution system. Navigant utilized a combination of metered data and engineering analysis to establish the total losses as well as determine an appropriate allocation to individual customer classes. [Client: Hydro One Networks, Inc.; Date: 2013; Location: ON, Canada]
- **Business plan review for RIIO-ED1.** Benjamin led a team that reviewed a Distribution Network Operator's (DNO) business plans submitted to Ofgem's under RIIO-ED1 (Revenue set to deliver strong Incentives, Innovation and Outputs). The team reviewed the business plans and the business plan consultation documents to: identify any missed opportunities or enhancements which could be embraced; provide a qualitative assessment of which network has a higher or lower probability of being fast-tracked in the RIIO process; and identify specific actions and priorities that would improve the chances of fast-track status. [Client: Confidential (Utility); Date: 2013; Location: London, UK]

- **Comprehensive review of the Global Adjustment.** The Independent Electricity System Operator retained Navigant to conduct a review of the Global Adjustment (GA) mechanism and to evaluate alternative cost recovery mechanisms. Benjamin was the project manager for this engagement. The GA is the largest of three mechanisms through which the IESO recovers the direct electricity supply cost from consumers. Navigant's review had five specific objectives: (i) to advise if similar charges to the GA exist in other North American jurisdictions, and if so to describe those charges and provide guidance on the advantages and disadvantages of employing a similar approach in Ontario; (ii) to identify more efficient options for recovering the GA costs from consumers, while allowing for greater responsiveness from customers; (iii) to consider the unbundling of the GA into component parts and an appropriate allocation of the costs on this basis; (iv) to consider the development of market mechanisms for customers and others to manage GA costs; and (v) to quantify the impact of recommended options. A substantial component of this engagement was consultation and facilitation with industry and government stakeholders. Navigant and the IESO consulted with stakeholders in advance, on the scope of the review, and subsequently throughout the review process. Navigant staff was responsible for facilitating two town-hall style events and for the preparation of consultation documents. [Ontario Independent Electricity System Operator; Date: 2013; Location: ON, Canada]
- **Impact of time of use rates and design considerations.** Engaged by the Ontario Energy Board, the province's regulator and electricity price-setting agency for a two-part study to: Part 1: Estimate the impact of the transition from tiered (i.e., inclining block) to TOU rates and Part 2: Use the results of this evaluation to estimate the impact on system peak demand and a variety of other metrics of four alternative TOU structures. Benjamin was the project manager for this engagement. [Client: Ontario Energy Board; Date: 2013; Location: ON, Canada]
- **Industrial Electricity Incentive program design.** Advised both the Ontario Power Authority and the Ontario Ministry of Energy on the development of the Industrial Energy Initiative (IEI), which effectively offers new and existing industrial load in the province premium rates for electricity. Advised on a number of program design issues including: appropriate tariff levels, the impact on other customer classes, eligibility criteria, and the role of energy efficiency, among other issues. [Ontario Power Authority; Date: 2012; Location: ON, Canada]
- **Evaluation of demand-side product pricing practices.** Benjamin was part of a team that assessed alternative methods and models for evaluating the cost effectiveness of demand-side pricing and interruptible load tariffs, and estimating the costs avoided by those resources. [Client: Tennessee Valley Authority; Date: 2012; Location: Tennessee, USA]
- **Development of risk-based compliance and enforcement framework.** Benjamin led an engagement with the Ontario Energy Board (OEB) to develop a risk-based approach to compliance for the electricity retailers and gas marketers segment of the energy sector. The development of a risk-based compliance framework builds on recent changes following the passage of the Energy Consumer Protection Act, 2010, which established a new framework for the regulation of retail activities and suite metering, and reinforced and expanded the OEB's consumer protection mandate. Navigant's scope of work consisted of three main elements: a review of other regulatory entities in Ontario and other jurisdictions that have implemented risk-based compliance frameworks; the development and recommendation of a compliance program framework; and implementation support. As part of the implementation, Navigant facilitated risk assessment workshops with OEB staff. [Client: Ontario Energy Board; Date: 2012-2013; Location: ON, Canada]

- **Discussion paper on incentive regulation mechanisms.** Benjamin prepared a detailed discussion paper on the current efficiency target incentive regulation framework in Ontario, including its history and evolution, and its applicability to Ontario Power Generation's prescribed nuclear and hydro-electric assets. Detailed case studies of other efficiency target regulatory regimes were also developed and included in the paper. [Client: Ontario Power Generation; Date: 2012; Location: ON, Canada]
- **Customer density and cost allocation study.** Benjamin and his team were engaged by Hydro One Networks, Inc. to review the existing density-based electricity distribution rate class design and cost allocation mechanisms. The objective of the study is to establish a set of well-defined and defendable customer classes that take into account appropriate density differentiation. Benjamin led a consortium of firms providing econometric, engineering, and strategic advice to Hydro One Networks, Inc. in order to complete the study and assist with preparations for an upcoming rate application. Benjamin led two stakeholder engagement sessions. The first, to garner input into the methodology development, and the second, following the completion of the study, to present the results and findings. [Client: Hydro One Networks, Inc.; Date: 2011; Location: ON, Canada]
- **Electricity distribution tariff design.** Provided advisory support to the Electricity and Cogeneration Regulatory Authority for the Kingdom of Saudi Arabia. Benjamin assisted in the development of a long-term electricity tariff model and framework designed to achieve revenue sufficiency for the electricity sector as a whole for several regulatory periods from 2008 onwards. The tariff design embedded efficiency targets and incorporated a lifeline tariff for residential customers. [Client: Electricity and Cogeneration Regulatory Authority; Date: 2007-2008; Location: Saudi Arabia]
- **Design of standard offer/feed-in tariff program.** Advised on various issues associated with the design of its initial renewable energy standard offer program, including: rationale for a standard offer; eligibility criteria; contract term; different approaches for establishing the standard offer price; and alternative incentive mechanisms for promoting on-peak generation. [Client: Ontario Power Authority; Date: 2005-2006; Location: ON, Canada]
- **Determination of avoided cost from energy efficiency measures.** Developed an estimate of avoided costs used to value conservation and demand management initiatives in Ontario. Developed models to estimate the avoided energy, capacity and transmission costs and system losses. Prepared informal testimony and presented results to staff at the Ontario Energy Board. Analysis was approved without a formal hearing and has been used by various parties to assess the value of different investment alternatives including district energy projects. [Client: Ontario Energy Board; Date: 2006; Location: ON, Canada]
- **Default supply pricing mechanism design and implementation.** Part of a team that provided consultancy services throughout the design and implementation of the Regulated Price Plan for provincial electricity consumers. Implementation included: developing the requisite forecasts for the Ontario wholesale electricity market; describing the precise methodology used to blend the costs from the various streams that contribute to the Regulated Price Plan supply; deriving final prices that consumers are charged under the Regulated Price Plan; and developing the final documents available for public consumption. Benjamin developed the blended cost model, which ultimately determined the rate passed on to consumers, assessed the impact of regulatory decisions, developing the two tier rates for conventional metered facilities as well as the three tier pricing structure for time of use metered facilities. Modelled the effect of a price-tier threshold adjustment on the generated revenues, determined offsetting adjustment required to maintain revenue neutrality. Analysed the key risk factors and sources of variance associated with the generated revenues and cost of supply for the Regulated Price Plan. [Client: Ontario Energy Board; Date: 2004-2005; Location: ON, Canada]

Testimony and Expert Witness Reports

- Hydro One Networks v. Ontario Energy Board (EB-2017-0049). Distribution Unit Cost Benchmarking Study: Pole Replacement and Substation Refurbishment. 2016-10-19. For the applicant
- Hydro One Networks v. Ontario Energy Board (EB-2016-0160). Total Transmission Cost Benchmarking. 2016-05-17. For the applicant
- Hydro One Networks v. Ontario Energy Board (EB-2013-0416). Distribution Line Loss Study. 2014-1-23. For the applicant
- Hydro One Networks v. Ontario Energy Board (EB-2011-11-11). Customer Density and Distribution Service Costs. 2011-11-11. For the applicant
- TransCanada Energy Ltd. (Claimant) and Ontario Independent Electricity System Operator (Respondent). Gas Delivery and Management Services Electricity Market Expert Report. 2016-03-24. For the respondent

Work History

Associate Director and Director, Navigant
Managing Consultant, London Economics International
Senior Associate, Ampersand Energy Partners
Consultant and Senior Consultant, Navigant
Junior Engineer, Power and Electro-technology, Hatch

Education

M.Sc., Management and Economics, London School of Economics and Political Science, London, UK
B.Sc., Applied Mathematics and Electrical Engineering, Queen's University, Kingston, Canada

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Professional Summary

Andy Tam is an Associate Director Managing Consultant in Navigant's Global Energy Practice. His experience spans projects with electric regulators, major generation/transmission/distribution utilities, and various other energy related public/private sector entities. Within these engagements, Mr. Tam has primarily focused on providing strategic advisory on electricity markets, utility financial modeling (working capital, cost of service, revenue requirement, valuation) and grid modernization technologies through working with entities such as the Ontario Energy Board (governmental regulator), Hydro One Networks Inc. (Ontario's largest distribution & transmission utility) and the United States Navy and Marine Corps (military).

Most recently, Mr. Tam participated in a project regarding regulatory rate design, helping a large island utility develop electricity rates from the revenue requirement stage through the cost of service and rate design stage. Furthermore, Mr. Tam has recently worked on technical and financial evaluations of Smart Grid/micro grid technologies, providing strategic due diligence for utility M&A, and performed regulatory cost of service/revenue requirement support for natural gas utilities. Mr. Tam has also completed financial working capital evaluations for three of the largest utilities in Ontario. Prior to joining Navigant, Mr. Tam worked at Hydro One Networks Inc. as a financial analyst, completing a two-year leadership rotation program where he worked on utility financial modeling, business planning, regulatory analysis and business process optimization. Throughout his career, Andy has developed a strong quantitative skill set and also brings forth software design experience from R&D at Nortel Networks. Mr. Tam received his Master of Business Administration (MBA) from the Ivey School of Business in London, Ontario, Canada and both his Bachelor of Science in Computer Engineering (Honours), and Bachelor of Arts in Economics degrees from Queen's University in Kingston, Ontario, Canada.

Professional Experience

Business Strategy

- Development of strategies and capital infrastructure projects to integrate energy and water/wastewater related data across the energy and water/wastewater supply chain for the US Navy and Marine Corps – increased the client's visibility into energy consumption, identified underperforming facilities and applied energy efficiency measures and smart grid strategies to determine project economics;
- Conducted M&A due diligence for various clients and investment bankers seeking to acquire generation, transmission and distribution assets – provided strategic advisory on revenue forecasts, capital expenditures and regulatory implications, which were key factors in determining bid prices for the infrastructure assets;
- Developed gas turbine market entry strategy for multi-national conglomerates by analyzing market segment attributes and identifying underserved segments – clients used the results to enter into the aeroderivative gas turbine market through the acquisition of an American aerospace manufacturer;
- Assessed financial risks for grid modernization projects – analyzed financial risks and applicant capabilities to execute and commercialize proposed smart grid projects as part of governmental smart grid fund;

- Assessed technical risks for grid modernization projects – analyzed technical risks and applicant capabilities to advance the smart grid, stimulate economic development and reduce technical risk in the energy sector as part of governmental smart grid fund;

Rates & Regulatory

- Conducted working capital financial modeling for distribution/transmission utilities across North America – quantified the level of working capital required to finance ongoing operations through lead-lag working capital studies;
- Developed a revenue requirement and cost allocation model that was used for electric rate structure negotiations for a large island utility – the rates calculated were an integral part of the utility's $9B debt restructuring plan, that provided creditors with a return, in addition to a feasible way to pay down the debt and to support the electric infrastructure;
- Developed electricity market pricing models in various jurisdictions across North America – analyzed generator outputs, market pricing metrics, system operator restrictions, and distribution/transmission costs to develop forecasts and hedging strategies for utilities, generation developers and various other clients;
- Developed financial models for energy storage project proposal – modelled competitive energy storage bid price for client's proposal to the local electricity markets regulator; this included the analysis of energy storage cost parameters as well as pro forma development for this project (balance sheets, income statements and cash flows);

Power Systems & Markets

- Established capital budgets and business planning for utilities across Canada – this included research, benchmarking and analysis on capital spending procedures, asset management, and regulatory approvals to develop sustainable long term strategies for clients;
- Developed interview instruments, conducted interviews, and performed research and analysis for regulators, expert panels, and various other electricity/natural gas entities – subject matters included regulator cost assessment models, potential new product development areas, and jurisdictional/franchisee agreements between municipalities and utilities;
- Analyzed electricity pricing metrics to develop forecasts and hedging strategies for various clients – market research tools used include SNL, Ventyx Velocity Suite, Sygration and ISO data;
- Evaluated services for Ontario's first micro grid demonstration project – provided technical advisory, project management and reporting services for a major distribution utility's micro grid demonstration project;

Education

MBA, Ivey School of Business – London, Ontario, Canada
BSc Engineering (Computer Engineering), Queen's University – Kingston, Ontario, Canada
BA (Economics), Queen's University – Kingston, Ontario, Canada

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Professional Summary

Michael De Paolis is a Senior Consultant in Energy practice at Navigant. Michael's work involves strategic consulting on the development of distributed energy frameworks for large utilities. His areas of expertise are generator connection impact modelling and risk mitigation based asset management. Michael has worked in many areas of the energy sector, with particular depth in renewables integration and cost of service assessments for power utilities. Michael is experienced in bringing a statistically rigorous approach to the analysis of distribution systems, and has played a significant role in building Navigant's renewables integration service offering.

Areas of Expertise

- **Compliance and Regulatory Control:** Provides support and technical expertise by participating in compliance assessments. Advises companies in the process of ensuring regulatory compliance to manage accounting exposure and financial risks.
- **Vendor Management:** Guides senior operations executives in enhancing third party vendor incentive models as well as call center agents' performance. Specializes in assessing operational, compliance, and strategic risks; opines on M&A risk control and operational strategy alignment.
- **Data Mining and Data Manipulation:** Performs in-depth data analysis and modelling to identify opportunities within finance models. Facilitates change and completes expense-saving projects for clients, largely within banking organizations.

Professional Experience

- Dominion Virginia Power: Applied statistical methodology for distribution system reduction. Using SynerGi, modelled photovoltaic integration impacts at the distribution level, and predicted uptake costs for various adoption scenarios. Developed new framework for assessing dynamic impacts of high penetration levels of solar generation and applied this framework to assess expected system costs.
- California Energy Commission: Applied statistical methodology for distribution system reduction of the Southern California Edision (SCE) distribution network. Using CYMDIST, modelled photovoltaic integration impacts at the distribution level, and predicted uptake costs for various adoption scenarios. Developed new framework for assessing advanced inverter technology and storage cost/benefits when integrating renewables, and assessed for the SCE network.
- Large eastern USA electrical utility: Developed statistical methodology for distribution system reduction. Using SynerGi, modelled photovoltaic integration impacts at the distribution level, and predicted uptake costs for various adoption scenarios.
- PG&E: Using CYMDIST, modelled photovoltaic integration impacts at the distribution level, and predicted uptake costs for various adoption scenarios. Developed a model to assess the dollar savings associated with distributed generation in the forecast period.
- Toronto Hydro Electric Systems Ltd.: Reviewed and verified accuracy of business cases filed as evidence for rate rebasing.

- Canadian electricity regulator: Developed review and restructuring of cost allocation methodology for streetlighting rate class customers of local electrical utilities.

Work History

Senior Consultant, Consultant, Navigant
Engineer in Training, Hydro One Networks

Education

Bachelor of Applied Science, Energy Systems, University of Toronto

INTERROGATORY RESPONSE - SEC-55

2-SEC-55

EXHIBIT REFERENCE:

[Ex.2-4-3, Attachment G]

SUBJECT AREA: Distribution System Plan

Question:

With respect to the METSCO Review of the Hydro Ottawa's Asset Condition Assessment Framework:

a) Please provide a copy of the retainer and any other instructions provided to METSCO.

b) Please provide a list of all information/documents/individuals that METSCO reviewed in its review.

c) [p.2] METSCO states: "In this regard, Hydro Ottawa has implemented a number of enhancements to the ACA framework since METSCO's initial assessment was performed".
   i) Please provide a copy of METSCO's initial assessment.
   ii) Please detail what "enhancements" Hydro Ottawa made.

d) [p.4] Please provide METSCO's assessment of Hydro Ottawa's ACA framework relative to other large utilities that it has familiarity with.

e) Please provide METSCO's views on what enhancements and improvements Hydro Ottawa should focus on to improve its ACA framework.

RESPONSE:

a) Please refer to Attachment CCC-56(A): METSCO Proposal.

b) Please refer to Attachment SEC-55(A): Document List for Metsco Review 2019. This attachment contains a list of the documents included in Metsco's review. Metsco did not review any individuals in its review.

c) i) For Metsco's initial assessment, please see Attachment CCC-60(A): Hydro Ottawa ACA Review - Initial Assessment.

ii) For enhancements and details that Hydro Ottawa made, please refer to Attachment CCC-60(B): Hydro Ottawa ACA Review - Follow Up Assessment.

d) Please see Attachment CCC-60(A): Hydro Ottawa ACA Review - Initial Assessment. Metsco has provided a maturity rating of Hydro Ottawa's ACA Framework, which is relative to utility best practice.

e) Please refer to page 3 of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review.[1]

[1] Please note that pages 2-4 of Attachment 2-4-3(M): Asset Condition Assessment - Third Party Review are erroneously labeled as Attachment G.

Document List for Metsco ACA review 2019

i. .ftpquots
ii. 08_HO DataLoader - DX Cable, DCAB 2019-02-01.xlsx
iii. 09_HO DataLoader - DX Cable, DPILC 2019-02-01.xlsx
iv. 10_HO DataLoader - DX Manholes, DMAN 2019-02-01.xlsx
v. 14_HO DataLoader - DX Pole, DPOLE 2018-01-22.xlsx
vi. 15_HO DataLoader - DX Reclosers, DOHRCL 2018-01-25.xlsx
vii. 16_HO DataLoader - DX SWGear UG & Vault 2019-01-31.xlsx
viii. 17_HO Dataloader - DX XFRMs, Polemount, DPXFRM 2018-01-29.xlsx
ix. 18_HO DataLoader - DX XFRMs, Underground, DUXFRM 2019-02-01.xlsx
x. 19_HO DataLoader - DX XFRMs, Vault, DVXFRM 2019-02-01.xlsx
xi. 21_HO DataLoader - DX Switch 2018-06-11.xlsx
xii. ACA AIP Implementation Roadmap - R0-13.pdf
xiii. AMI Planning process.png
xiv. Asset Refistry.xlsx
xv. GEG0001.pdf
xvi. Station HI_METSCO -Oct 3 2018 Phil Update.xlsx
xvii. Overhead Assets (Poles, Transformers, Switches&Reclosers).pdf
xviii. Station Breaker - Air.pdf
xix. Station Breaker - Oil.pdf
xx. Station Breaker - SF6 (and reclosers).pdf
xxi. Station Breaker - Vacuum.pdf
xxii. Station Circuit Switcher (& 44 kV breaker).pdf
xxiii. Station Trans Insulation & Bushing Power Factor.pdf
xxiv. Station Trans Insulation Res & Polarization Index.pdf

xxv. Station Trans Manual TTR.pdf

xxvi. Station Trans Tap Chander Inspection.pdf

xxvii. Sation Trans Winding Res & TTR.pdf

xxviii. Underground Switchgear - Padmounted & Vault.pdf

xxix. Underground Transformers - Padmounted & Vault.pdf

xxx. Underground Vault Inspections.pdf

INTERROGATORY RESPONSE - SEC-56

2-SEC-56

EXHIBIT REFERENCE:

[Ex.2-4-3, Attachment J]

SUBJECT AREA: Distribution System Plan

Question:

With respect to the EA Technology ISO 55000 Gap Analysis:

a) Please provide a copy of the retainer and any other instructions provided to METSCO.

b) Please provide a copy of the CVs of the authors of the report.

c) Please provide a table that includes: a) Each recommendation, b) Hydro Ottawa's response, and c) time-frame for implementation.

RESPONSE:

a) Hydro Ottawa is interpreting this question as referring to EA Technology, as opposed to Metsco.

Hydro Ottawa has attached a copy of the EA Technology ISO 55000 Gap Analysis proposal as Attachment SEC-56(A): EA Technology Proposal.

Please see Attachment SEC-56(B): ISO 55000 Gap Analysis Statement of Work for the instructions provided to EA Technology.

b) Please see Attachment SEC-56(C): EA Technology ISO 55000 Gap Analysis - Author CV.

c) A table of Hydro Ottawa's response to the recommendations resulting from the ISO 55000 Gap Analysis can be found in the response to interrogatory OEB-58 part (g).



ISO55000 Gap Analysis

Prepared for: Hydro Ottawa

Project No: P13185
Document Version: 2
Date: 30 October 2018

Asset Management and Infrastructure Consultancy
P13185-2

Version History

Date	Version	Author(s)	Notes
October 28, 2018	1	A McHarrie	
October 30, 2018	2	W. Higinbotham	

Final Approval

Date	Version	Author(s)	Signature
October 30, 2018	2	W. Higinbotham	

Customer Acceptance

Date	Version	Author(s)	Signature

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Appendices

Appendix I Terms and Conditions
Appendix II Maturity Scoring
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1. Our Understanding of your Requirements

Hydro Ottawa has requested that EA Technology provide a proposal that specifies how EA Technology can provide support to determine the maturity of Hydro Ottawa's Asset Management System by assessing it against the requirements specified within ISO55001.

2. Scope and Objectives

The scope of this project is to carry out an ISO55000 gap analysis on Hydro Ottawa's Asset Management System. The gap analysis assessment will quantify Hydro Ottawa's Asset Management System against each of the requirements specified within ISO55001.

The objective of this project is to:

- Determine the maturity of Hydro Ottawa's Asset Management System
- Identify the gaps between Hydro Ottawa's Asset Management System and the requirements specified within ISO55001; and
- Providing recommendations to close the identified gaps.

3. Gap Analysis

3.1 Task 1: Project initiation

3.1.1 Request Documentation

In order to maximise the time spent during the gap analysis assessment, EA Technology will request some relevant asset management documentation for review. The high-level documentation requested will be to provide EA Technology's Asset Management auditors with a background understanding of Hydro Ottawa's Assets, Organisational structure, Objectives and geographical spread.

The documentation will be requested prior to the gap analysis during the 'Kick Off' meeting, which will be carried out at the start of the project.

3.1.2 Kick Off Meeting

EA Technology will initiate the project with an initial 'Kick Off' meeting, which will discuss:

- The scope of the gap analysis;
- The organisational structure that the gap analysis will cover;
- Possible dates for the gap analysis to be carried out.

The 'Kick Off' meeting will be carried out over skype or tele-conference facilities and information gained during the 'Kick Off' meeting will be used to create a schedule for the gap analysis.

3.1.3 Gap Analysis Schedule

EA Technology will create a gap analysis schedule, which will provide a timetable of meetings, interviews and site meetings, plus:

- Which ISO55001 requirements will be being audited during each meeting, interview or site meeting;
- Who will be required to attend each audit (departments and roles);
- What Start-up, review and close out meetings will be carried out.

The gap analysis schedule will be used to manage the gap analysis assessment and will be delivered to Hydro Ottawa at least two weeks previous to the gap analysis assessment so that Hydro Ottawa can arrange for the correct members of staff to be available for the correct meetings.

3.2 ISO55000 Gap Analysis

3.2.1 Start Meeting

EA Technology will meet with Hydro Ottawa's project team at the beginning of the gap analysis, to explain the gap analysis and to introduce EA Technology's audit team. The meeting will illustrate how EA Technology will conduct each of the meetings/interviews and how each requirement will be scored.

3.2.2 Gap Analysis meetings/Interviews

EA Technology will measure the maturity of Hydro Ottawa's Asset Management System against the requirements of ISO55001. The gap analysis will be conducted through the employment of EA Technology's bespoke gap analysis tool, which is based on the IAM's Self-Assessment Methodology tool (SAM). The gap analysis tool will record relevant information and score the maturity of different parts of Hydro Ottawa's Asset Management System against the relevant requirements of ISO55001 (Appendix II).

ISO55000 defines an Asset Management System as a set of interrelated and interacting elements of an organisation, whose function is to establish the asset management policy and asset management objectives, and the processes, needed to achieve those objectives. Therefore, even if an organisation does not have what could be described as a well-defined Asset Management System, EA Technology's experienced Asset Management consultants using the gap analysis tool can:

- Identify systems and processes within the organisation that could be used as part of Hydro Ottawa's Asset Management System.
- Identify areas that currently do not conform to the requirements identified within ISO55001
- Make recommendations for areas that do not currently conform so that conformity can be obtained.

The gap analysis assessment will be carried out through a series of interviews and site meetings as defined in the Audit Schedule. The gap analysis activities will take place over a four-day period and will be carried out by an experienced EA Technology audit team, comprising of a Lead and Support auditor. The Lead Auditor will conduct each interview in-line with the pre-determined Audit Schedule to evaluate:

- The levels of conformance with the requirements specified within ISO55001;
- The maturity of Hydro Ottawa's Asset Management System by quantifying the degree of conformance against each ISO55001 element;
- The size of the gap for between the constituent parts of Hydro Ottawa's Asset Management System, and what ISO55001 specifies;
- What needs to be carried out to close any identified gaps.

At the beginning of each interview EA Technology will provide some awareness to Hydro Ottawa staff involved in the audit process. This ensures staff are aware of their role during the audit plus it generally makes staff being interviewed feel more at ease with the audit process.

3.2.3 Final Presentation

At the end of the gap analysis assessment, EA Technology will carry out a high-level collation of the collected data, and will carry out a closing presentation to relevant Hydro Ottawa stakeholders of the initial findings of the gap analysis. As the gap analysis will be scored as the audits progress, a representation of the findings will be included in the final presentation.

3.3 Gap Analysis Report

EA Technology will provide Hydro Ottawa with a gap analysis report within 20 working days of the end of the gap analysis assessment. The report will document:

- The information obtained during the gap analysis assessment to provide a narrative assessment of Hydro Ottawa's readiness to undertake an ISO55000 certification audit;
- Areas of strength and weakness within Hydro Ottawa's Asset Management System;
- Any aspects of Hydro Ottawa's culture and practices that may challenge the implementation of Hydro Ottawa's Asset Management System;
- Evidence produced as part of the gap analysis that proves conformity or part conformity of ISO55001 requirements;
- Identified gaps between Hydro Ottawa's Asset Management System and the requirements of ISO55001;
- Recommendations of follow-up actions that will address the identified gaps;

EA Technology will also use its experience with other worldwide organisations to illustrate a generic view of cultural attributes that can be used by an organisation to help promote the successful adoption and application of asset management. The gap analysis report will be completed and supplied within twenty working days of the end of the gap analysis assessment.

4. Benefits of Employing EA Technology

As an organisation EA Technology are patrons of the IAM, plus we are also endorsed Assessors and endorsed trainers under the IAM's Endorsed Assessor and Trainer schemes. EA Technology are enthusiastic members of the patrons' group, as the group's purpose is to foster and promote best practice application of Asset Management theory, principles and techniques, plus it supports the establishment and recognition of appropriate training and competence for individuals and benchmarking for corporate achievement.

EA Technology also encourages and supports its staff on an individual level, to become involved in developing the discipline of Asset Management through being:

- Patron representatives;
- IAM Council membership;
- Individual members of the IAM;
- On organising committees for Asset Management conferences;
- Reviewers of Asset Management papers;
- Contributing members of Asset Management working groups

4.1 IAM Patrons

The Patrons of the IAM are an exclusive group of Corporate Members who commit to a high level of activity and engagement with the Institute. The IAM Patrons group help the IAM focus on relevant projects and work that will deliver the greatest progress for the discipline and practice of Asset Management. In exchange for significant support to the Institute, Patrons have great influence not only on the direction of the IAM itself but also on the development of the discipline of Asset Management.

4.2 IAM Council

EA Technology are members of the IAM council, whose focus and responsibilities are to develop the subject of asset management and increase the influence of the IAM. Council is consulted on major IAM policy decisions and regularly reviews strategy and plans for all aspects of IAM activity.

4.3 Endorsed Assessors

Any organisation could declare themselves to be a Certification Body and issue a certificate of conformity for an ISO management system standard such as ISO 55001; however, the importance of attaining compliance with an ISO management system standard, is the benefit to the organisation from implementing the management system, and not the receiving of a certificate. Therefore; it is crucial that an organisation outsources its assessment and certification requirements, to an organisation that it has confidence, in their competence and capability to carry out such services.

It was for this reason that the IAM operate its Endorsed Assessor scheme, as the IAM believed it is important to assist organisations in finding and accessing suitable and reputable assessment providers, which will deliver relevant, good quality asset management assessments using knowledgeable assessors.

Endorsement as an Endorsed Assessor covers assessment against ISO 55001 and/or PAS 55 for gap analysis and/or certification. EA Technology has been assessed by the IAM against the requirements of the Endorsed Assessor scheme and has been successfully appointed to the status of Endorsed Assessor.



EA Technology can confirm that we are approved Assessors through the IAM's approved assessor scheme. Proof of EA Technology's endorsed status can be found on the following link:

https://theiam.org/professional-development/endorsed-assessors-and-trainers/iam-endorsed-assessor-scheme/iam-endorsed-assessors-listings/

4.4 Endorsed Trainers

The IAM Endorsed Trainer Scheme is designed to assist organisations find suitable and reputable training providers that deliver relevant training using knowledgeable instructors. Endorsed Training Providers are endorsed for one or more of the endorsed courses covered by the Endorsed Trainer Scheme, EA Technology currently are Endorsed Trainers for their 'Introduction to Asset Management' course.



EA Technology can confirm that we are approved Trainers through the IAM's approved trainer scheme. Proof of EA Technology's endorsed status can be found on the following links:

https://theiam.org/professional-development/endorsed-assessors-and-trainers/iam-endorsed-trainers-scheme/iam-endorsed-trainers-listings/

4.5 BSI AMS/001 Asset Management

EA Technology have two representatives on the British Standards Institute working group for Asset Management (AMS/001). The scope of AMS/001 is:

- Under the direction of the Standards Policy and Strategy Committee, is responsible for the UK input into ISO/TC 251 and standardisation in the field of asset management.

As members of AMS/001, EA Technology has been instrumental in the direction and content of the ISO55000 suite of documents. For example, EA Technology representation has recently guided the content change proposed for the new version of ISO55002 (Asset management -- Management systems -- Guidelines for the application of ISO 55001).

4.6 TC123

EA Technology is currently looking to have representation on the new Technical Committee 123 "Standardisation of the management of assets in power systems"

4.7 Project Experience

EA Technology has extensive experience in supporting companies around the world develop Asset Management systems, strategies and plans towards achieving Asset Management excellence. We have worked with many utilities and other worldwide organisations to improve their Asset Management capabilities, develop their Asset Management strategies, implement Condition Based Risk Management solutions (investment decisions) and prepare asset data strategies as part of wider Asset Management strategy/policy development and implementation assignments.

EA Technology has diverse experience and widespread expertise in Asset Management- as a discipline. Furthermore, EA Technology is referenced as a key member to the original BSi PAS55:2008, and was a contributing member to the new standard of ISO55000, sitting on the UK mirror committee. EA Technology also sits as a contributing member to the revision of the IAM Asset Management Anatomy which is the industry wide overarching document regarding Asset Management.

The following are details of a number of projects that EA Technology have worked on over the last 5 years, which illustrate a wide range of experience in helping clients develop and implement Asset Management Systems derived from ISO55000 and the earlier PAS55 standard.

4.8 Project 1

Project Title	Lansing BWL - Substation Asset Management Assessment		
Name of Client	Country	Nature of Business	Nature of Project
Lansing BWL (89170)	USA	Lansing Board of Water & Light. Utility, providing drinking water, electricity, steam and related services to the Greater Lansing area in Mid-Michigan.	Asset Management program implementation
Project Start Date	2/2015	Project End Date	6/2017

Detailed Description of Project

Lansing BWL wanted to understand the current condition of its substation Assets and to implement a program of activity to develop a comprehensive asset register, maintenance plans and long-term refurbishment and replacement plans in line with Industry best practices and consistent with future SAP system implementation requirements.

Lansing BWL, as part of its Asset Management program had a desire to assess the condition of its substation Assets utilising industry best practice techniques and to develop a comprehensive asset register and repository for testing/results to assist with the development of maintenance plans, budgetary plans and long-term refurbishment and replacement plans considering:

- Asset criticality
- Regulatory required testing and maintenance
- Industry best practices

EA Technology developed and populated a repository for testing and maintenance data/results. This contained relevant existing Lansing BWL testing and maintenance records made available to EA Technology from existing repositories, together with data and results from the condition assessment activity. EA Technology provided a written update of Lansing BWLs existing T&D Substation Maintenance Plan and Procedures, to reflect industry best practice techniques. Recommendations were made where appropriate, considering maintenance and testing procedures, cycles, manufacturer's recommendations, regulatory requirements and industry best practice.

An audit of existing electrical Asset maintenance procedures was performed against existing testing and maintenance records and develop a database of equipment found to be out of compliance with maintenance/testing requirements. This database also reflected recommendations for further action derived from the condition assessment findings.

A work plan of gap closure activities was developed to address equipment testing and maintenance gaps. This included recommendations on how to best accomplish the testing/maintenance work and any associated staff training and/or additional resource required. EA Technology Provided recommendations to support the best use of asset register data. Guidance was provided as to the most appropriate use of data, both for future integration into SAP and the potential implementation of further analytic/maintenance/decision support software tools available to support and enhance Lansing BWL Asset Management capability.

The benefit of carrying out the condition assessment of the assets is to enable Asset Management decisions to be made based on an accurate understanding of asset condition rather than just age.

4.9 Projects 2, 3 and 4

Project Title	Guernsey Electricity - Asset Management Gap Analysis ISO55000 Asset Management System Implementation Asset Class Taxonomies			
Name of Client	Country	Nature of Business		Nature of Project
Guernsey Electricity	UK (Channel Island)	Guernsey Electricity Generate, distribute and supply electricity and electrical products throughout the Island of Guernsey.		Asset Management Gap Analysis and Implementation
Provided Project Start Dates	Gap Analysis 10/2015	Project End Dates	ISO55000 Gap Analysis 11/2015	
	Implementation 1/2016		Implementation 03/2018	
	Asset Class Taxonomies 10/2017		Asset Class Taxonomies 11/2017	

Detailed Description of Project

Gap Analysis

EA Technology undertook a gap analysis of Guernsey Electricity's asset management system against the requirements of ISO55001. The project undertook a gap analysis assessment, which identified and evaluated areas of non-compliance, and made recommendations for improvement.

The gap analysis was carried out using the Institute of Asset Management (IAM) SAM assessment methodology During the gap analysis workshops, EA Technology interviewed relevant stakeholders and reviewed various asset management documents in order to evaluate the maturity scale of each section of the ISO55000 standard.

The key objectives pursued during the Gap Analysis assessment were:

1. Ascertainment of empirical evidence of the level of application of asset management techniques promoted by ISO 55000, with a view to assessing the level of maturity with the requirements specified within ISO55001. This was based on the gap analysis workshops with key members of staff and a brief appraisal of some top-level documentation provided to EA Technology during the workshops.
2. Evaluation against a recognised baseline benchmark so that the assessment has its foundation in a commonly available framework. This enabled the results to be viewed in isolation with confidence or be seen in the context of expectations for other organisations or business sectors. The IAM SAM Assessment Methodology has been developed to provide the framework for such assessments.
3. Provide Guernsey Electricity with a better understanding of good practice in asset management in the context of ISO 55001 requirements, identifying areas of excellence which already demonstrate high levels of conformity, or areas which appear to be deficient or misaligned. The latter might be actual shortcomings or could be due to lack of evidence of activity or association within the example documentation provided.

Asset Management System Implementation

This objective of this was to build on the recommendations produced from the Gap Analysis assessment to implement an ISO55000 compliant Asset Management System. The project was structured into three basic phases, which are Implementation, Embedding and Evaluation. The following is a summary of the main work carried out in each phase:

- Implementation
  - Close the identified gaps (carry out recommendations detailed in the Gap Analysis Report);
  - Amend or create business processes that support the continued employment of Asset Management activities
  - Provide Asset Management training on Asset Management Systems and Asset Management activities (promote Asset Management knowledge and awareness);
  - Implement an effective organisational structure;
  - Implement an effective Information System that supports Guernsey Electricity's Asset Management Plans (determination of what data is required by the organisation to accomplish the Asset Management Plans);
- Embedding
  - Supervised the employment of Asset Management activities;

- Formed and led the Asset Management Working Group;
- Provided Asset Management support.

- Evaluation
  - Gap Analysis to assess the new Asset Management System

Asset Class Taxonomies/Ontologies

The purpose of this project was to develop asset class taxonomies/ontologies, which will be used to define how Asset Data is structured and linked. EA Technology supplied an experienced Asset Management Consultant to review each Asset Class with their respective Asset Controllers to develop an Asset Class Taxonomy/Ontology.

EA Technology reviewed each of the asset classes defined by Guernsey Electricity to develop asset class taxonomies/ontologies in an excel spreadsheet format that will define:

· Logical Asset Hierarchies

· A set of Code Lists

· Asset Data Characteristics

The output of this project was five asset class taxonomies/ontologies that specify the grouping, structure and linking of assets and their subcomponents. These taxonomies/ontologies will provide a framework for Guernsey Electricity's Information system, and the format will allow it to be easily uploaded into any new enterprise information system that Guernsey Electricity may employ.

4.10 Project 5

Project Title	Tri-State - Independent assessment of Tri-State's processes and approach to Asset Management in the Transmission division (Phase 1 Gap Analysis)		
Name of Client	Country	Nature of Business	Nature of Project
Tri-State	USA	Electricity Transmission	Strategic Asset Management
Project Start Date	6/2014	Project End Date	8/2014

Detailed Description of Project

Tri-State invited EA Technology to undertake an independent assessment of Tri-State's processes and approach to Asset Management in its Transmission division. The primary project deliverables included:

1) A Report on what PAS 55 expects, what had been observed, what was deemed good, what was deemed deficient, an overall score based on the methodology, and suggested improvement opportunities set out for each of the 28 elements of PAS55.

2) The Development of an indicative roadmap, developed in conjunction with Tri-State, to address/close the gaps identified by PAS55 analysis. The roadmap set out a prioritised plan of improvements aligned to Tri-State's strategic objectives, thus providing a useful set of waypoints for the next part of Tri-State's Asset Management implementation journey.

The assessment was conducted using the Institute of Asset Management's PAS 55 Assessment Methodology (PAM).

4.11 Project 6

Project Title	Altalink Circuit Breaker Condition Based Risk Management Model		
Name of Client	Country	Nature of Business	Nature of Project
Altalink	USA	Electricity Transmission	Strategic Asset Management
Project Start Date	6/2017	Project End Date	1/2018
Detailed Description of Project			
Altalink stated that they were actively looking to develop investment support tools for a range of asset classes, including the development of a Condition Based Risk Management (CBRM) circuit breaker model. In addition, they indicated that they wished to draw upon EA Technology's vast experience in this area to support the development of similar models involving overhead lines, transformers and a financial risk quantification process. EHV and transmission voltage circuit breakers are complex multi-component items of plant, which can be managed through modelling of the circuit breaker's health index (HI), probability of failure (PoF), consequences of failure (CoF), Risk and NPV.			

4.12 Project 7

Project Title	Asset Condition Assessment (ACA) methodology		
Name of Client	Country	Nature of Business	Nature of Project
Hydro Ottawa	USA	Electricity Transmission	Strategic Asset Management
Project Start Date	7/2018	Project End Date	2/2018
Detailed Description of Project			
Hydro Ottawa carried out a project to develop a new asset management investment tool, which was designed to replace their current Asset Condition Assessment (ACA) methodology. The decision support tool under development is based upon CNAIM, (Common Network Asset Indices Methodology), which was developed as part of the license conditions of the current Ofgem regulatory price control period referred to as RIIO-ED1 in Great Britain. CNAIM has been created by UK DNO's with assistance from EA Technology. In Q1 of 2017, Hydro Ottawa published an RFP, in which EA Technology were invited to outline the details of a proposed project to assist them with the development of the new asset investment models. This project included a review of the current processes and practices employed by Hydro Ottawa. As a result of this review EA Technology made specific recommendations in areas identified as being in need of improvement, and supported Hydro Ottawa with their asset management development project.			

4.13 Project 8

Project Title	Dhofar Power Company – Internal Auditing		
Name of Client	Country	Nature of Business	Nature of Project
Dhofar Power Company (DPC)	Oman	DPC transmit, distribute and supply electricity throughout the Salalah region of Oman,	ISO55000 Internal Auditing Service
Project Start Date	8/2017	Project End Date	02/2018
Detailed Description of Project			
EA Technology carried out an Internal Audit of DPC's Asset Management System between the dates of the 13th and the 17th of August 2017 (inclusive). The audit was carried out at DPC's Head Office in Salalah, plus two site visits within the Salalah area. The Internal Audit covered all of the sections and sub-sections detailed within ISO55001 and was carried out by EA Technology's principal consultant Andrew McHarrie, who is an approved assessor under the Institute of Asset Management's approved assessor scheme. During the Internal Audit 122 discussions were held and scored to evaluate their content and whether they could be supported by evidence. Any concerns were also scored to reflect their perceived risk to the Asset Management System and the organisation as a whole. The scoring of any areas of concern against perceived risk allows the organisation to prioritise any remedial actions. As a result of the 122 discussions held as part of the Internal Audit, a number of areas of concern were identified, which were classified as 'Minor' or 'Moderate' risks. The identification of these areas of concern is seen as a positive action, which will enable DPC to improve its Asset Management System through continual improvement.			

4.14 Project 9

Project Title	PAS55 Certification		
Name of Client	Country	Nature of Business	Nature of Project
Abu Dhabi Distribution Company (ADDC)	Abu Dhabi	ADDC distribute electricity and water supplies throughout Abu Dhabi	Certification Service
Project Start Date	9/2014	Project End Date	11/2014
Detailed Description of Project			
Abu Dhabi Distribution Company (ADDC) invited EA Technology to provide consultancy services to provide assessment and certification aligned to PAS 55:2008-1. The project included both desk-based activity delivered from the UK and an Assessment Audit completed in Abu Dhabi. ADDC successfully passed the certification audit and EA Technology issued ADDC with a certificate of conformance against the PAS55 standard.			

4.15 Project 10

Project Title	From PAS55 to ISO55000 Certification		
Name of Client	Country	Nature of Business	Nature of Project
Abu Dhabi Distribution Company (ADDC)	Abu Dhabi	ADDC distribute electricity and water supplies throughout Abu Dhabi	ISO55000 Gap Analysis
Project Start Date	7/2015	Project End Date	7/2016
Detailed Description of Project			
After ADDC achieved PAS55 certification their objective changed to achieving the new Asset Management standard ISO55000. EA Technology carried out an assessment of their suitability of achieving ISO 55000. This consisted of a gap assessment and creation of a road map to ensure ADDC fulfilled the requirements of ISO55000. It also covered the main changes from PAS 55 to ISO 55000 in Leadership & Planning, Performance Evaluation, and Continual Improvement.			

EA Technology employs over 200 staff, many professionally qualified to PhD, MSc, M/BEng, BSc level in their chosen disciplines who possess a wide range of engineering and business capabilities and a wealth of practical experience in managing utilities assets. Furthermore, many of the company's management team and senior consultants have direct experience of working in electricity businesses or equipment manufacturers and have first-hand knowledge of the issues associated with managing large scale Utility networks.

As a core service offering EA technology has a significant pool of staff with broad asset management experience, many of whom are active members of the Institute of Asset Management (IAM) who were the architects of the BSI PAS55 specification and key participants in the development of ISO55000. EA Technology has key experience in PAS55 and ISO55000 Assessment and in supporting the enhancement of Company's Asset Management capabilities towards ISO55001 certification and beyond.

5. Project Management

EA Technology uses a formal project management structure, which starts at the proposal stage by making sure that all deliverables are understood and defined and specifying what work EA Technology will carry out in order to deliver these requirements. If the proposal is successful, then it is used as the blueprint for the project management of the project, which will ensure the correct delivery of the defined deliverables, within the agreed timescales.

EA Technology have a proven track record of managing and delivering high quality results for its Asset Management projects. This is achieved through the selection of an experienced project manager, who is responsible for:

- Leading a specially selected team;
- Communicating with the client;
- Supervising the project team on a day-to-day basis;
- Achieving the project objectives.
- Fulfilling the contract within time and cost limits;
- Managing expectations and ensuring the highest level of client satisfaction is achieved;
- Remain responsive to changes in needs throughout the project;

As a core service offering EA technology have a significant pool of staff with key experience in providing guidance and support in the development of Asset Management best practices, performing Asset Management assessments and developing policies, tools and techniques to support Asset Management best practice.

The project organisation will be structured to support effective management and delivery of the project tasks through:

- A Project Manager, who will be key point of contact with day to day responsibility for delivery of the tasks and all commercial aspects such as project planning; reporting; change management; internal liaison.
- The support of technical leaders who will take responsibility within their teams for resource management; technical leadership; task allocation; checking and verification.
- Technical direction from key specialist to support technical delivery

CVs have been supplied for members of EA Technology who have been identified as having experience pertaining to this project and could be involved as part of EA Technology's delivery team (Appendix III). It can be seen from the CVs that all of the proposed members of EA Technology's project team have previously worked for UK DNOs, plus they have also carried out many Asset Management projects for worldwide Network Operators, which has provided them with good knowledge and experience of electrical transmission and distribution organisation's Asset Management Systems.

EA Technology also has many subject matter experts that can be called upon to assist with the project if and when required. EA Technology Ltd reserve the right to select alternative staff members from its pool of highly experienced consultants, should the above consultants detailed in Figure 1 be unavailable at time of order placement.

Our proposed team for this commission would be led by Andrew McHarrie, Principal Consultant and EA Technology's Head of Asset Management and Power System Studies. Whilst we will do our best to ensure named Consultants are available to undertake the work for Hydro Ottawa, you will appreciate that they are in demand by our customers and so their availability will be determined in part by the timely award of the contract

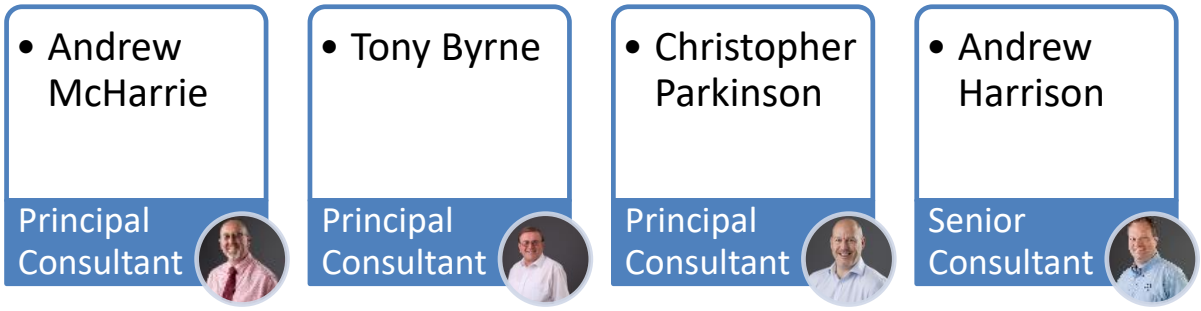


Figure 1 - Asset Management Consultants

6. Timescale

Figure 2 illustrates the proposed timeline for the ISO55000 project. It can be seen that the project can be carried out over a three-month period, from project start up to the delivery of the gap analysis report. This illustrates that even if the project is not started until the new year, EA Technology can still deliver the project before the deadline of the 31st March 2019.

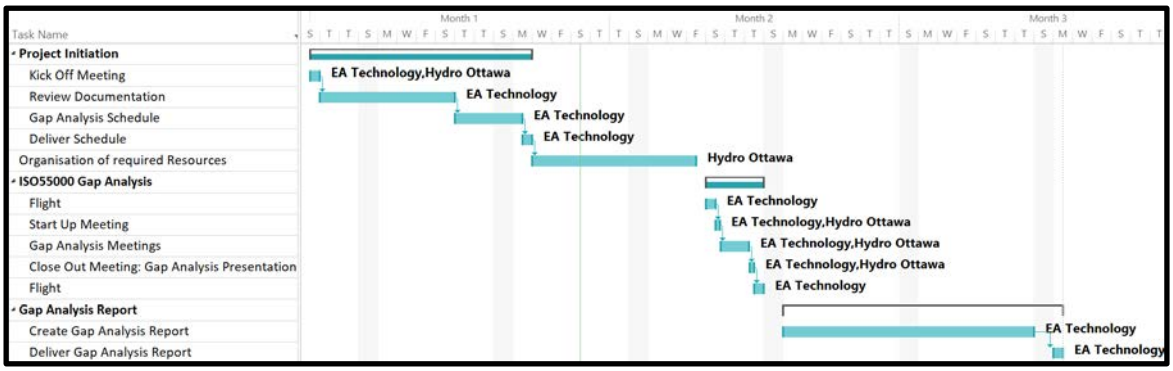


Figure 2 – ISO55000 Gap Analysis Project Timeline

Appendix I Terms and Conditions

STANDARD CONDITIONS FOR SUPPLY OF GOODS AND SERVICES

These conditions set out the terms on which **EA Technology Limited** ("**we**") have agreed to supply our services to the Customer ("**you**"). They also set out the terms on which any goods supplied by us in connection with such services are supplied:-

1. DEFINITIONS

For ease of reference certain terms used elsewhere in these conditions are defined as follows:-

"Goods" means any machinery, tooling, apparatus, materials, products, goods and articles of any kind (including, without limitation, the Software) supplied by us to you in connection with the provision of the Services;

"Intellectual Property Rights" means any patent, copyright, design right, trade mark, confidential information, know how and all similar rights whether or not registered or capable of registration arising from the performance of the Services or the supply of the Goods.

"Price" means the price specified in the quotation together with value added tax and any other applicable taxes or duties.

"Services" means the work and services which we have agreed to carry out for you (including where appropriate the supply of any Goods). The Services are more fully described in the accompanying quotation.

"Software" means any software supplied by us to you, which form part of the Goods.

"writing" includes facsimile transmission, electronic communication and comparable means of communication and "written" shall be construed accordingly.

2. APPLICATION OF CONDITIONS

2.1 We agree to carry out the Services and to supply Goods on the terms of these conditions only. We will not be bound by any contrary, different or additional terms or conditions contained or referred to in your order form or other documents or correspondence; nor will we agree to any addition, alteration or substitution of these conditions unless they are expressly accepted by us in writing by a person authorised to sign on our behalf.

2.2 Each order or acceptance of a quotation for Goods and/or Services by you shall be deemed to be an offer by you to buy Goods and/or Services subject to these conditions.

2.3 No order placed by you will be deemed to be accepted by us until a written acknowledgement of order is issued by us, or if earlier Goods and/or Services are supplied by us to you.

2.4 We reserve the right without notice to amend the specification of our goods from time to time so that the descriptions thereof as set out in our catalogues, advertising literature or quotations may change and you are advised to check the specification before placing your order. To enable us to pursue our policy of continuous improvement of our goods and services, we shall be entitled to make any alterations which we consider to be reasonable in the specification or scope of such goods and/or services whether before or after the making of the contract.

3. OUR OBLIGATIONS

3.1 The scope of the Services is set out in the quotation. We will perform those Services with reasonable skill care and diligence. We will use reasonable endeavours to provide the Services within any time scale indicated in the quotation.

However, that time scale is only an estimate and accordingly we can accept no responsibility or liability, financial or otherwise in the event that we are unable for any reason to keep to the timetable.

3.2 We may perform the Services ourselves or where at our discretion we consider it necessary or desirable we may instruct third parties to carry out the whole or any part of the Services on your behalf.

3.3 Where we have agreed to supply Goods the description of those Goods is set out in the quotation. Unless the quotation provides otherwise no other descriptive material or specification whether written or oral contained in any correspondence or statement or in promotional or sales literature shall form any part of our agreement.

3.4 We may suspend or cease performance of the Services or delivery of Goods at our discretion if at any time you are in breach of your obligations under these conditions or we have reason to believe that you may not be able to pay your debts as they fall due or you cease, threaten to cease or we have reason to believe that you may cease trading or there is any change in your ownership or control which for whatever reason we consider makes it unsuitable or undesirable for us to continue to work for you and in any such case we shall notify you in writing and on such notification we shall have no further liability or obligation to you.

4. PRICE AND PAYMENT TERMS

4.1 You are to pay the Price in the manner and at the times mentioned in the quotation or if there is no such time or method mentioned in full in cleared funds not later than thirty days after the date of our invoice to you. Time for payment by you shall be of the essence.

4.2 If payment is not made by the due date we may:

4.2.1 charge interest on the amount outstanding at the rate 8% above Svenska Handelsbanken AB base rate applicable from time to time until payment, whether before or after judgment and you shall pay the interest on demand. We may in the alternative claim interest at our discretion under the Late Payment of Commercial Debts (Interest) Act 1998; and/or

4.2.2 suspend all Services until payment has been made in full.

4.3 We are not obliged to start work unless and until you shall have paid to us such sums by way of deposit as shall be specified in our quotation or otherwise agreed between us. If any other monies are not paid by the due date we shall be entitled to stop any work which we are doing on your behalf in relation to the provision of the Services and to suspend delivery of any Goods which may be due. We may also at our discretion take any other action which is open to us as at law as we may think fit.

4.4 All prices quoted to you are based on information available to us at the time of quotation. Our Price does not include the cost of carriage, packing, customs duties, insurance or any other similar item, which shall be payable by you. In the event that any third party providing services to us which are part of the Services specified in the quotation shall raise its charges to us we reserve the right to pass on those increased charges to you in addition to the sum quoted in the quotation.

4.5 You agree that we may review and increase our charges, provided that such charges shall not be increased more than once in any 12 month period. We will give you written notice of any such increase at least 2 months before the proposed date of the increase. If such increase is unacceptable to you, you may, within 3 months of such notice being received, terminate our agreement giving not less than 3 months written notice to us.

4.6 In the event that performance of the Services requires us to travel the cost of all travel, accommodation and subsistence incurred by our employees or any third party contractor in the performance of the Services shall be included in the Price unless expressly stated otherwise.

4.7 We reserve the right to raise an additional charge on you in the event that the assumptions specified in the quotations prove to be incorrect for whatever reason and in particular we reserve the right to increase the Price if work has to be performed outside normal working hours or if the nature, extent or scope of the Services is altered in any way during the course of our providing the Services. We also reserve the right to increase the Price if delays are caused or if we have to carry out extra work as a result of anything which you may do or fail to do.

4.8 You shall make all payments due under the Agreement in full without any deduction whether by way of set-off, counterclaim, discount, abatement or otherwise, unless you have a valid court order regulating an amount equal to such deduction to be paid by us to you.

5. YOUR OBLIGATIONS TO US

5.1 You must promptly provide us with all information and assistance that we may reasonably require in connection with the performance of the Services.

5.2 Where the Services are to be provided at your premises or elsewhere than at our premises you are to make available free of charge all gas, electricity, heating and water required by us together with such facilities for the use of our employees and any third party contractors as shall be required in order to enable us to comply with relevant legislation concerning their health, safety and well-being and to perform the Services.

5.3 You are to carry out any preparatory works specified in our quotation in good time to enable the Services to be supplied promptly and effectively.

5.4 You are to disclose to us the presence of any hazardous machinery or substance in any place where we are to provide the Services and to give us full information as to the nature of any such hazard. If you do not do so we may refuse to perform or to complete the Service without being under any further obligation to you.

5.5 You are to obtain any necessary consents or permits required from any local or governmental authority to enable the Services to be carried out.

6. INTELLECTUAL PROPERTY RIGHTS

6.1 The Intellectual Property Rights shall remain our property unless and to the extent stated in the quotation. Provided that you comply with all your obligations as to payment and otherwise we grant to you a personal non-exclusive licence to use the Intellectual Property Rights in the normal course of your business but not further or otherwise. You may not grant any sub-licence nor transfer the benefit of the licence hereby granted without our prior written consent. If our agreement terminates, this licence shall automatically terminate.

6.2 Copyright in all drawings, reports, calculations and other documents provided by us in connection with the Services belongs to us. You may not make copies of the same or any part of them without our agreement which must be in writing to be valid.

6.3 Where any Software (including without limitation any bespoke software) is provided by us the copyright in such Software shall remain our property and you shall use the same only as provided in the software licence to be entered into or entered into between us.

6.4 If the quotation expressly states that Intellectual Property Rights in connection with the Services or any part thereof are to become your property you will grant to us a non-exclusive royalty free licence to use the same for all purposes connected with our business without limit of time and in particular to use the Intellectual Property Rights and any development thereof which we may undertake in connection with Goods and Services supplied by us to our other customers.

6.5 Unless we have told you otherwise to the best of our knowledge and belief neither the supply of the Goods nor the supply of the Services to you will result in the infringement of any third party's Intellectual Property Rights. In the event however that any claim is made against you by any third party for infringement of such rights as a result of your use of any Goods or Services supplied by us we reserve the right at our own expense to conduct

any ensuing litigation and all negotiations for a settlement of the claim. We will bear the cost of any payments (either by way of a lump sum or a continuing royalty payment) made in settlement or as a result of an award in a judgement against us in the event of litigation.

6.6 We will grant you the benefit of condition 6.5 only if you give to us the earliest possible notice in writing of any such claim being made or action threatened or brought against you, you make no admission of liability and take no other action in connection therewith, you permit us to have the conduct of the claim and give us all reasonable information, cooperation and assistance in relation to the conduct of the claim (including lending your name to proceedings). In addition, if it is made a condition of any settlement made by us or judgement awarded against you, you will return or destroy as applicable all infringing Goods or documents still under your control subject to a refund by us of any payment for such goods already made (less a reasonable allowance for depreciation).

6.7 The provisions of Condition 6.5. shall not apply to any infringement caused by us in following a design or instruction furnished or given by you nor to any use of the Goods or Services in a manner or for a purpose which shall have been specifically prohibited in writing by us nor to any infringement which is due to the use of such Goods or Services in association or combination with any other product.

6.8 You warrant that any design or instruction furnished or given by you shall not be such as will cause us to infringe any intellectual property rights of any third party and shall indemnify and keep us indemnified in full against any loss, damages or expense whatsoever (including costs) which we may incur in or arising from the performance of the contract by reason of any infringement of any such proprietary right.

6.9 The provisions set out in condition 6.5 above state our entire liability to you and your sole and exclusive remedies against us in connection with claims based on or resulting from the infringement of intellectual property rights of any kind whatsoever of any third party.

7. CONFIDENTIALITY

Both of us are to keep confidential and shall not without the prior consent in writing of the other disclose to any third party any technical or commercial information which may have been acquired from the other as a result of discussions, negotiations and other communications between us relating to the Services or the Goods. These obligations continue after termination of our agreement however caused.

8. RELIANCE ON SKILL AND JUDGEMENT

You acknowledge that you rely on your own skill and judgement in determining the suitability of the Goods and the Services for any particular purpose. You are alone responsible for ensuring that any performance requirement indicated in the quotation is sufficient and suitable for your purpose save in so far as we have expressly agreed in writing that you may rely on our advice.

9. LIABILITIES

9.1 We do not accept liability in any circumstances and whether in contract, tort or on any other basis whatsoever and however caused for:

9.1.1. any loss of profit, business, contracts, revenues or anticipated savings; or

9.1.2. any special, indirect or consequential damage of any nature whatsoever.

9.2 Subject to Condition 9.1, and to the overall limitations on liability set out below we will accept liability to you for any loss and/or damage arising by reason of negligence on the part of our employees or any breach on our part of our contractual obligations to you.

9.3 Our total liability to you whether in contract tort (including negligence or breach of statutory duty) breach of third party rights or otherwise howsoever arising shall not in any event exceed whichever shall be the lesser of one million pounds and five times the Price.

9.4 In so far as we are able to do so and at your expense we will assign to you the benefit of any warranties and conditions relating to quality, suitability, fitness for purpose or quiet possession contained in any contract which we may have with any third party for the supply of any component included within the Goods.

9.5 You accept responsibility for any inaccuracies, errors or omissions on your part in relation to instructions given by you or in any data, drawings, calculations, specifications, information or material supplied to us for the purpose of enabling us to make the Goods or perform the Services.

9.6 We will not accept any liability for any loss arising as a result of delay howsoever caused.

9.7 Termination of our agreement for whatever reason shall not affect any rights or liabilities which have already accrued at the time of termination.

9.8 Nothing in these conditions excludes or limits liability:

9.8.1 for death or personal injury caused by our negligence; or

9.8.2 for any matter which it is illegal for us to exclude or attempt to exclude our liability; or

9.8.3 for fraudulent misrepresentation.

10. DEFECTS

In the event that defects appear in the Goods and/or the Services within a period of twelve months in respect of Goods (excluding Software) or the Services and a period of three months in respect of Software supplied by us after the date of delivery thereof we will make resources available to investigate such defects and provided that in the case of Goods and Software the Goods and Software have been properly used, cared for and maintained by you we shall endeavour to rectify the defect. Provided that the defect arises solely as a result of faulty design materials or workmanship on our part such attempt at rectification shall be carried out free of charge to you.

11. YOUR INDEMNITY TO US

11.1 We require you to indemnify us from and against all claims, actions, demands, proceedings, damages, costs, charges and expenses arising out of or in connection with the supply of the Goods and Services to you:

11.1.1 to the extent that any such claim etc shall exceed the limit of liability specified in condition 9.3 above; and

11.1.2 where any such claim or loss arises as a result of any breach on your part of any of your obligations under these conditions; and

11.1.3 in any event where such claims or actions are brought or threatened against us by a third party as a result of your use of the Goods or the Services in the manufacture, supply or distribution of any other goods or in the provision of a service to a third party.

11.2 Neither we nor you shall be liable for any loss or damage arising from any occurrence unless a claim is formally notified in writing before the expiry of two years from the date of our quotation.

12. TIME AND FORCE MAJEURE

12.1 Unless expressly so stipulated by you and agreed in writing by us, time for performance of the Services shall not be of the essence.

12.2 We will not be in any event be responsible for any delay in or failure to perform the Services or to supply the Goods which is caused by factors beyond our reasonable control which shall include but not be limited to acts of God, acts of governmental or any other lawful authority, strike, war, riot, civil commotion, flood, fire, explosion, epidemic, trade embargo or any other acts or omissions on the part of any third party or sub-contractor or any failure of electricity or other fuel or equipment, provided that if the event in question continues for a continuous period in excess of 3 months, you shall be entitled to give written notice to us to terminate our agreement.

13. ASSIGNMENT AND AGREEMENT

13.1 We may assign our agreement or any part of it to any person, firm or Supplier.

13.2 You may not assign our agreement in whole or in part without our prior written consent (not to be unreasonably withheld or delayed).

13.3 The quotation and these conditions sets out the entire agreement and understanding of both of us relating to the subject matter thereof and supersedes all prior discussions between us and all prior memoranda of intent or understanding and all previous documentation. You acknowledge that you have not relied on any statement, promise or representation made by us or given on our behalf, which is not set out in these conditions. Nothing in this condition shall limit or exclude any liability for fraud.

14. RETENTION OF TITLE AND RISK

14.1 Where Goods are to be supplied to you they will remain our property until you have paid for both Goods and Services in full.

14.2 Whilst the Goods remain in our ownership you may not sell or permit any lien to be created over them and you shall take proper care of the Goods and keep them separate from your own goods and clearly identified as belonging to us.

14.3 Unless otherwise agreed, the Goods shall be at your risk as from the time they leave our premises and whether or not delivered to you or to any agent on your behalf.

15. VARIATION

15.1 Subject to condition 2.5, no variation of our agreement or these conditions shall be valid unless it is in writing and signed by or on behalf of each of the parties.

16. WAIVER

If either of us shall positively waive or delay or not insist in any instance on full compliance by the other with any of these terms that shall not prevent him from subsequently requiring such compliance in respect of that instance by the other party (subject always to reasonable notice in the case of a positive waiver).

17. GOVERNING LAW AND DISPUTES

The construction, validity and performance of the agreement between us shall be governed in all respects by English law and we each agree to submit to the non-exclusive jurisdiction of the English courts.

18. NOTICES

Any notice required or permitted to be given by either party to the other under these conditions shall be in writing addressed to that other party at its registered or principal places of business or such other address as may at the relevant time have been notified pursuant to this condition 17 to the party giving notice.

19. GENERAL

19.1 Nothing contained in these conditions shall or shall be deemed to constitute a partnership or a contract of employment between the parties.

19.2 The parties to this Agreement do not intend that any term of these conditions shall be enforceable by virtue of the Contracts (Rights of Third Parties) Act 1999 by any person that is not a party to it.

January 2016

Appendix II Maturity Scoring

EA Technology will apply the IAM's scoring criteria to all of the ISO55001 sections assessed during the Gap Analysis and Stage 1 and Stage 2 audits. The scoring criteria represents five "levels" of asset management maturity (Level 0 to Level 4). The maturity levels as defined by the IAM are summarised as follows:

- Maturity Level 0 (Learning)
  - The elements required are not in place. The organisation is in the process of developing an understanding of ISO 5500.
- Maturity Level 1 (Applying)
  - The organisation has a basic understanding of the requirements It is in the process of deciding how the elements will be applied and has started to apply them.
- Maturity Level 2 (Embedding)
  - The organisation has a good understanding of ISO 5500. It has decided how the elements of ISO 5500 will be applied and work is progressing on implementation.
- Maturity Level 3 (Optimising and Integrating)
  - All elements of ISO 5500 are in place and are being applied and are integrated. Only minor inconsistencies may exist.
- Maturity Level 4 (Beyond ISO 55000)
  - Using processes and approaches that go beyond the requirements of ISO 5500. Pushing the boundaries of asset management development to implement new concepts and ideas.

An overall maturity score is recorded numerically and plotted as a radar chart for the main sections of ISO 55001. It is normal practice for this type of audit assessment to be conducted by holding facilitated interviews, workshop meetings and site visits with a representative cross section of staff involved in the asset management process. By seeking honest and frank answers to the assessment questions, it is possible to quickly establish the current status of the organisation's maturity level and conformity to the requirements of ISO55001.

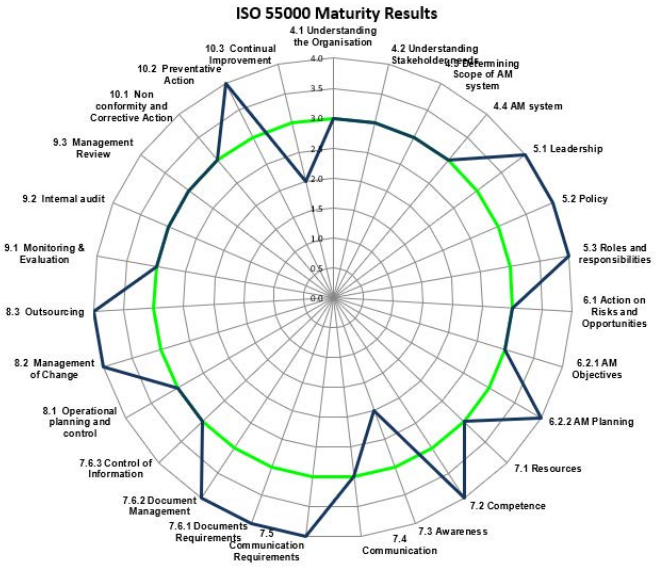


Figure 3- ISO55001 Maturity Assessment

Appendix III CVs



Profile

A Principal Consultant with a breadth of knowledge and experience in the electrical utility sector specialising in Asset Management and Overhead Lines. With a proven track record of managing businesses and projects, Andrew has the ability to deliver good quality work, on time, in scope and within budget.

Synopsis

- Andrew is a Principal Consultant who currently holds the position of Head of Asset Management and Power System Studies.
- He has over 40 years' experience in the electrical utility sector, since he started work as an apprentice electrician in the late seventies
- Andrew is a chartered engineer and a Fellow of the IET
- He joined EA Technology Ltd in 2011 from Line Design Ltd where he was the Managing Director, carrying out consultancy work that specialised in condition monitoring of overhead line assets.
- Andrew has vast experience of distribution Overhead Lines from a construction, operation, service provision and consultancy perspective.
- Andrew also has actively been involved in the assessment of many organisation's Asset Management Systems.
- Andrew has also been used as an expert witness, in a number of Wood Pole and Overhead Line related incidents that have resulted in serious or fatal injuries.

Qualifications and Memberships

- Chartered Engineer and Fellow of the Institution of Engineering and Technology (CEng, FIET)
- BSc Hons Computing and Design, Open University
- Certificate in Asset Management, The Institute of Asset Management
- Member of Institute of Asset Management (MIAM)
- Member of the British Standards AMS1 working group

Skills and Responsibilities

- Experienced Project Manager
- Experienced Asset Management Auditor
- ISO55000 Internal Auditor
- ISO 9001 Internal Auditor
- Detailed Knowledge of Overhead Lines
- Ex Senior Authorised Person (Overhead Lines)
- Vast experience in data collection and condition inspection of electrical assets.
- Detailed knowledge of wood pole testing and failure analysis.
- Good organisational skills having successfully started and run several successful businesses.

Career Summary

- 2011 to Present: EA Technology Ltd, Principal Consultant, Network Asset Management
- 2010 to 2011: Line Design Ltd, Managing Director
- 2001 to 2010: Poletecs Ltd, Managing Director/Operations Manager
- 1999 to 2002: Shomac Power Services Ltd, Managing Director
- 1978 to 1999: Manweb/Scottish Power, Electrician, Chargehand Linesman, Team Leader

Personal Interests

Passionate about furthering the discipline and general understanding of Asset Management.

Outside work Andrew enjoys travelling, classic cars and computer coding - he lives with his wife in North Wales.

Experience

Best Industry Practice Manual
Client: Solar Trade Association

Andrew was a contributing author of the STA's best practice manual on the management and mitigation of network outages for Distribution Network Operators (DNOs), and for solar farms connected to their networks.

ISO55000 Documentation
Client: Quintas Energy

Andrew assisted Quintas Energy's Asset Management staff create their Asset Management Policy, Asset Management System document and Strategic Asset Management Plan document.

ISO55000 Internal Audit
Client: Dhofar Power Company (DPC)

Andrew carried out an Internal Audit of DPC's Asset Management System and provided DPC with a list of findings that were evaluated in-line with their risk management process.

ISO55000 Internal Audit
Client: Guernsey Electricity

Andrew carried out an Internal Audit of Guernsey Electricity's Asset Management System and provided them with a list of findings that were evaluated in-line with their risk management process and incorporated within their risk reporting structure.

Incident Report Review
Client: Osbourne Clarke

Andrew carried out a review of an incident report that detailed an overhead line failure for one of Osbourne Clark's clients.

Asset Management System Implementation
Client: Guernsey Electricity

Andrew assisted Guernsey Electricity with the implementation of their Asset Management System from recommendations provided by a previous ISO55000 gap analysis. Andrew assisted with the creation, development and editing of Asset Management documentation, processes and organisational structure.

ISO55000 Gap Analysis
Client: Quintas Energy

Andrew carried out an ISO55000 gap analysis on Quintas Energy's Asset Management System. The gap analysis assessment tested the maturity of Quintas Energy's Asset Management System and provided guidance on how to become ISO55000 compliant.

Asset Management System Document
Client: Manx Utilities

Andrew assisted Manx Utilities develop an Asset Management System document for Manx Utilities that specified their Asset Management System.

ISO55000 Training and Document Review
Client: Foresight

Andrew provided a two-day ISO55000 training course and advised Foresight on

the hierarchy and content of their Asset Management documentation.

HV Code of Practice Review
Client: Environment Agency
Andrew assisted the Environment Agency with the review of their HV Code of Practice document and provided recommendations for its improvement.

PAS55 to ISO55000
Client: Dhofar Power Company (DPC)
An evaluation of DPC's Asset Management documentation was carried out and changes were implemented to the document hierarchy and document content

Electrical Safety Rules Review
Client: PA Consulting
Andrew carried out the role of a technical expert, for PA Consulting during the execution of their contract with Network Rail, to review and recommend amendments to their Electrical Safety Rules to ensure compliance with the Electricity at Work Regulations.

2015 PAS55 Certification Audit
Client: Abu Dhabi Distribution Company (ADDC)
A Certification Audit was carried out on ADDC's Electric and Water distribution businesses against the PAS55 Asset Management Standard.

Expert Witness
Client: Health and Safety Executive
Andrew provided an expert opinion on the maintenance activities carried out on an overhead line, prior to a fatal incident involving contact with a high voltage conductor and farm machinery. The maintenance activities and the maintenance policies and procedures of the DNO involved were assessed against relevant regulatory requirements and benchmarked against all the other UK DNOs to ascertain compliance with industry best practice.

Medium Voltage ABC
Client: Tenaga Nasional Berhard Research (TNBR, Malaysia)
This project evaluated TNB's Medium Voltage ABC Network and benchmarked it against the rest of the world to identify areas for improvement. This involved evaluation of TNB's policy and procedural documentation and work processes for construction, operation and maintenance of its MVABC network.

Safety Assessment of Live Line Tree Felling Equipment
Client: Scottish and Southern Energy Power Distribution
This project evaluated the safety risks to a tree harvesting machine operator working in close proximity to overhead power lines. The project assessed the dangers a harvester machine operator would face if a tree they were harvesting touched an overhead power line with voltages from 11kV to 400kV. This safety argument was used as part of an ENA Engineering Recommendation.

Mechanical Sensors to Detect Broken and Low Hanging Conductors
Client: UK Power Networks
This project was prompted from a fatal incident caused by a low hanging conductor. The project looked at whether a low hanging conductor could feasibly be detected with the use of mechanical sensors. This project researched currently available products and systems, and a number of low hanging conductor scenarios were evaluated against standard distribution overhead line designs.

Wood pole failure investigations
Client: Health and Safety Executive
Andrew investigated a fatality caused by the failure of a wood pole being worked on. The investigation evaluated the work carried out before the fatal incident, the cause of the failure, the DNO's policies and procedures, regulatory and legal compliance and benchmarked the working practices with industry best practices.

Papers Published
'*JOURNEY FROM PAS 55 TO ISO 55000*', Co-Author, August 2015 for CIRED (Malaysia)



Profile

Tony Byrne is a Lead/Principal Consultant in the Smart Interventions Department. He has over 40 years' experience working with an electricity network operator and EA Technology, and is able to provide technical and practical advice to clients on a range of projects.

Qualifications and Memberships

- BSc (Honours) in Electrical Engineering
- Diploma in Management Science.
- Member of the Institution of Engineering and Technology (MIET)
- Chartered Engineer
- IAM Certificate in Asset Management
- Internal QMS Auditor (LRQA Certified)
- Individual Member of CIGRE; Ex-Member of CIGRE UK Executive Committee

Skills and Responsibilities

- Experienced Project Manager
- Leading and participating in Project Teams
- Development and review of policy/procedures and implementation
- Failure and Defect Investigation including development of remedial action plans
- Company representative at National and International Conferences and industry meetings / working groups
- Initiating and managing R&D projects
- Auditing plant and documentation

Career Summary

- 2011-date EA Technology – Principal Consultant, Asset Management & Policy
- 1974-2010 Electricity North West Ltd /United Utilities / Norweb. Variety of roles including:
  - Electricity Equipment Condition Manager
  - Network Policy & Standards Manager
  - Plant Policy Manager
  - Asset Replacement Manager (11kV)
  - Depot Manager
  - Circuits Policy Engineer
  - LV Faults Engineer

Experience

EA Technology

2018 STA Best Industry Practice Guide
Client: Solar Trade Association

Lead Author for the development STA Best Industry Practice Manual on the management of network constraints on solar generation sites, published by the STA in July 2018. Available for free download at https://www.solar-trade.org.uk/best-industry-practice-manual-management-network-constraints-solar-pv-generation-version/

2018 Review of contaminated oil in a 50MVA 132KV transformer
Client: Foresight Group

Review oil analysis reports and provide an opinion on the condition of the transformer with recommendations for action to be taken.

2018 Technical Assistance
Client: Confidential

Provide technical assistance to the owner of a wind farm for the adjudication of a contract dispute after a switchgear failure caused a prolonged outage at a wind generation site.

2018 Review of Safety Rules and Maintenance Policy
Client: Calor Gas UK

Development of a policy for the inspection and maintenance of electrical infrastructure equipment for introduction at all sites in the UK, including suggested maintenance frequencies and an outline of maintenance activities for all equipment types.

2018 Review of Solar Farm Transformer-Switchgear
Client: Equitix Ltd

Review of installed substations on a PV generation site and on-site condition assessment.

2017 Transformer Condition Assessment
Client: Magnetar Solar (UK) Ltd

Review of documentation and condition assessment of transformers on PV sites.

2017 Asset Condition Assessment and Taxonomy
Client: Calor Gas UK

Condition assessment of the HV electrical infrastructure at a site in the UK; development of asset taxonomy and data catalogue for those assets and population of the asset register from data collected; review of reports on the ENA NEDeRS system for client's HV switchgear with recommended actions.

2017 Asset Taxonomy
Client: Guernsey Electricity

Development of an asset taxonomy and data catalogue for generation, subsea cable, electricity distribution, protection and civil assets.

2017 Review of HV Switchgear Maintenance
Client: Vector Ltd, New Zealand

Review of maintenance policy for Long & Crawford oil filled HV switchgear.

2017 Technical Review of HV Substation Equipment
Client: Littlewood Solar Ltd

Review of installed substations on a PV generation site against design specification and assessment against relevant legislation and standards.

2017 Electrical Apparatus Maintenance Procedures
Client: Oikos Storage Ltd

Development of maintenance procedures for HV and LV electrical distribution equipment.

2016 Review of Incidents
Client: Quintas Energy, UK

Review of incidents causing generation constraints to PV sites due to planned and unplanned distribution network outages; development of methodology for categorising PV sites by type of connection to DNO network.

2016 Review of HV Maintenance
Client: AWE, UK

Electrical Infrastructure Audit and Maintenance Review at a UK site.

2016 Witness Testing on Switchgear
Client: AWE, UK

Independent witness of assessment tests on retrofit vacuum circuit breakers at 2 UK manufacturers.

2016 Review of HV Maintenance
Client: Oikos Storage Ltd

High level review of HV electrical maintenance and development of factors for risk assessment in the event of equipment failure on an oil/petrol storage site.

2015 ISO 55000 AM Strategic Guidance & Gap Analysis
Client: Guernsey Electricity, UK

Carry out ISO 55000 gap analysis and define the actions required to achieve accreditation.

2015 Asset Condition Assessment and Maintenance Audit
Client: Lansing BWL, Michigan, USA

Audit covering substation equipment from 4kV to 138kV:

- Development and population of an asset register
- Review of the asset maintenance plan and procedures
- Development of new maintenance manual and procedures
- Development of roadmap of actions to achieve company objectives.

2015 Electrical Infrastructure Audit – Review of 2011 Audit
Client: Huntsman Pigments, 3 sites

Review of 2011 audits of policy and procedure documentation for the electrical infrastructure and substation assessments at sites in France, Italy, and Malaysia.

2014 Review of Maintenance Strategy and Planning Process
Client: CLP, Hong Kong

Review of maintenance strategy, maintenance procedures and the planning process for scheduling maintenance activities; reviewed the RCM maintenance study process and developed a risk/criticality methodology for failure modes; proposed a range of KPIs for monitoring maintenance achievement.

Papers Published

- T Byrne, "Research into Plant Condition – The Strategic Technology Programme", Euro TechCon 2002, Birmingham, UK.
- J.R. Brailsford, D.T. Hughes, T. Byrne, C. Ross, A Programme for Effective Research into Substation Plant Condition, CIRED 2003, Barcelona, Spain
- T Byrne, Failure of Distribution Class Switchgear, EuroDoble Conference 2005, Oslo, Norway
- T Byrne, A Thomas, Implementation of Asset Risk Management in Distribution Networks, Euro TechCon 2005, Chester, UK
- R Zhang, T Byrne, D Jones, Z D Wang, A Technical Experience During Network Asset Replacement: Investigating Cable and Transformer Switching Interactions, CIRED 2010, Lyon, France
- T Byrne, Humidity Effects in Substations, PCIC Europe Conference, 2014, Amsterdam, Netherlands
- T Byrne and P Jewell, Flooding Issues, Actions Following Floods and Possible Mitigation Measures, Euro TechCon 2014, Stratford-upon-Avon, UK
- T Byrne and A Preece, Humidity Effects in Substations, PCIC Middle East Conference, 2015, Abu Dhabi, UAE



Profile

Andrew is a practical and pragmatic asset management consultant and professional electrical engineer. He has project managed and delivered some of the largest and high profile CBRM projects EA Technology have ever undertaken.

His ability to visualise difficult theoretical concepts and complex systems whilst maintaining a keen eye for detail contributes greatly to his success. Andrew has a great sense of humour, and is highly regarded as one of the most charismatic trainers within the EA Technology PowerSkills Centre.

Synopsis

- Andrew is a Senior Consultant for EA Technology's SMART Interventions business.
- Its aim is to support the strategic choices for energy network customers through its consultancy services and embedded software platforms, with core offerings related to quantifying & reducing investment uncertainty for power assets, improving network resilience and addressing future demands.
- He has over 17 years' experience of working in the UK electricity industry, joining EA Technology in 2011.
- Andrew has a background in fault investigation, network performance and reliability improvement within the UK electricity sector – which includes network automation and self-recovery.
- He has extensive experience as a Senior Authorised Person and has been responsible for drafting statutory emergency plans.
- Andrew is regarded as a CBRM specialist with delivery of integrated projects in electrical and gas sectors.
- Andrew is actively engaged with the IAM, and is contributing to the creation of the Subject Specific Guidelines.
- He is an IAM endorsed PAS55/ISO55000 Auditor, and a PowerSkills Centre approved technical trainer.

Qualifications and Memberships

- CEng MIET - Chartered member of the Institute of Engineering & Technology
- M.Eng (Electrical & Electronic Engineering), Heriot Watt University, Edinburgh.
- MIAM - Member of The Institute of Asset Management
- IAM Certificate in Asset Management

Skills and Responsibilities

- Electrical distribution network operation, maintenance, fault identification and recovery, repair, testing, supply restoration, testing, commissioning & automation.
- Responsibility for the project management and delivery of Condition Based Risk Management (CBRM), and asset management projects using multi-disciplinary teams.
- Continuous development of EA Technology's flagship CBRM methodology.
- Delivery of Common Network Asset Investment Methodology implementations.
- Responsibility for Asset Investment Management, (AIM) sales activity across the Americas.

Career Summary

- 2011 – present: EA Technology Ltd
- 2001 – 2011: SP Energy Networks
- 2001 – 2006: SP Power Systems
- 1996 – 2001: [Heriot Watt University]
- 2000 – 2001: Norweb Distribution

Personal Interests

A firm believer in the benefits of developing robust asset management cultures using approaches based upon sound engineering principles with a view to achieving system outperformance.

Outside work Andrew has a wide range of interests including scuba diving, snowboarding, mountain biking and 4x4 driving competitions. He holds an Advanced Driving Licence and races a Bowler Tomcat.

Experience

EA Technology

Public Safety Audit
Client: ESBN

ESBN commissioned EA Technology to complete an independent audit of their public safety activities to check for compliance with regulatory license conditions. This audot was carried out in two parts, a desktop documentary review and a through a series of onsite inspections and interviews with a cross section of ESBN staff.

Condition Based Risk Management Client: SSEPD & SHETL

Development and delivery of a complete suite of CBRM 2.0 models for all SSEPD assets reportable under RIIO-ED1. This implementation has significantly enhanced SSEPD's asset management capability, and decision making ability.
This project included the development and delivery of investment models for 'core' transmission assets up to 400kV.

PAS55 Audit & Gap Analysis
Client: Tristate

Perform an assessment of Tri-State's current asset management approach/processes against the PAS55 structure. Identify areas for improvement based on current goals and objectives, and develop a road map with implementation steps and benefits case.

Condition Based Risk Management
Client: Rio Tinto Alcan.

Rio Tinto Alcan invited EA Technology to apply Condition Based Risk Management (CBRM) to a selection of their electrical infrastructure assets which support their Canadian Aluminium smelting operations. The model developed during this project will help shape Rio Tinto Alcan's future investment programme.

Asset Health and Risk Study
Client: Ergon (Australia)

The objective of this assignment was to assess the condition of all electricity distribution network assets and the risks presented to the business. The work involved the development of a range of investment options to reduce risk and improve network performance, maximising investment benefits within imposed capital budget constraints.

PAS55 Asset Management Training
Client: Tenaga Nasional Berhad (TNB).

ILSAS - TNB, Malaysia asked EA Technology to provide a bespoke training course on Asset Management including the principles of BSI PAS 55.

This project was so successful that subsequently EA Technology has worked in partnership with TNB to obtain PAS55 certification for the Melaka region electricity distribution business. Melaka is regarded as the Centre of Excellence within this region.

An Introduction to asset management
Client: Oman Electricity Holding Company

This project involved the development of a bespoke training delivery that was designed to provide a general introduction to asset

management into this region. The course included an overview of asset management from first principles, asset management standards, and an outline of what makes an asset management system successful.

Scottish Power
Project Manager – Distribution Network Investment (Switchgear Replacement)

Responsible for the delivery of capital investment programme (predominantly 11kV Switchgear), and project managing the delivery of infrastructure for other project work streams.

Design Engineer – Network Improvement / Network Controllable Points Project

This c£58m project involved rogue circuit performance analysis, fault trending and root cause analysis. This was followed by the creation of bespoke circuit performance enhancing designs, their implementation and financial monitoring or the improved network performance.

Part of a small team to undertake competitor modelling and analysis; support operational efficiency and Regulatory outperformance programmes; develop cross-group (UK and Spain)

Project Engineer – CR2 (Control, Restoration & Repair)

This role was centred around emergency response to network faults, and the restoration of customer supplies, before undertaking necessary repairs. Vast experience of cable, overhead line and plant faults at 11kV and 33kV.

Project Engineer – Operations Dept. West of Scotland Region

This operational role involved the planning, design and execution of a wide variety of maintenance, new connections, refurbishment and construction projects using multi-disciplinary teams.

Papers Published

'Combining Load and condition based risk models for integrated investment planning', Co-Author, June 2013 for CIRED.

References

Landel C Johnston

Business IT Transformation Special Projects Manager
Scottish & Southern Electricity Networks
T: +44(0)1738 456360
E: Landel.c.Johnston@sse.com



Profile

A principal consultant with over 30 years' experience in technical and strategic management of electricity networks. Capable of quickly adapting to changing environments, Chris's personal skill set affords innovative thinking and problem solving together with meticulous planning and management in support of success.

Synopsis

- EA Technology Smart Interventions business professional specialising in maintenance strategies, policy and documentation development and management support systems.
- Providing support on strategic choices for energy network customers through both consultancy services and embedded software platforms, with core offerings related to quantifying & reducing investment uncertainty for power assets, improving network resilience and addressing future demands.
- Over 30 years' experience in the electricity energy sector joining EA Technology in 2007

  Electricity industry roles and responsibilities include network asset management and asset corrective maintenance strategies, management of network faults and supply restoration teams, management of asset renewal programmes, failure investigations and root cause analysis, senior authorised person duties and mentor training.
- EA Technology experience includes the provision of high-quality asset management systems to the industry, optimising value of infrastructure assets, research and development, factory acceptance testing (FAT), quality management systems, failure investigation and repair and providing regulatory advice to senior executive team members

Qualifications and Memberships

- HNC Electrical and Electronic Engineering
- Institution of Engineering and Technology member
- Institute of Asset Management corporate member
- Institute of Asset Management corporate asset management award panel member
- Cigré A2 UK Liaison group attendee

Skills and Responsibilities

- Regulatory advisor to senior executive team members
- ISO 9001 Quality Management Systems accredited auditor
- ISO 55000 and PAS 55 Asset Management training, implementation and auditing
- Factory Acceptance Testing (FAT)
- Technical due diligence for investors
- Develop, implement and review Electricity Safety Rules and Environmental Health and Safety Management Procedures
- Competence training and assessment
- Electrical equipment safe operation and maintenance techniques
- Electricity equipment failure investigation, analysis and repair
- Conversant with UK Independent Connections Provider (ICP) procedures ensuring electricity networks are installed to guaranteed adoptable standards
- Proven project management skills through effective communication and leadership of multi-disciplined teams

Career Summary

- 2007 - Present: EA Technology: Senior; Principal Consultant
- 2005 – 2007: Integrated Utility Services Ltd: Senior Project Engineer
- 2003 - 2005: Powermann Ltd: Area Manager
- 1984 - 2003: North Eastern Electricity Board (NEEB), Northern Electric Plc, Northern Electric Distribution Ltd: Various roles

Personal Interests

Supporting the positive psychology of achieving excellence to maintain an optimistic and rewarding attitude to life.

An appetite for travel and embracing different cultures.

A passionate supporter of Newcastle Utd F.C. as well as a keen golfer and scuba diver, living with much-loved family in North East England.

Experience

Public Safety Audit
Client: ESBN DAC; Republic of Ireland

Undertake a third-party audit of asset management policies, procedures and working practices to confirm regulatory compliance.

Renewable Energy Support Services
Clients: Various; UK

Provide support services to the Renewables Energy Sector including electrical infrastructure assessments, guidance on the durability and life expectancy of electrical apparatus, technical review of ICP and O&M documentation.

Professional In-house Support Services
Client: The Regulation and Supervision Bureau, Abu Dhabi

Undertake a 12-month overseas secondment to the Regulation and Supervision Bureau in the Emirate of Abu Dhabi (the Regulator for power, water and wastewater) providing technical expertise on the enforcement of relevant laws for the licensing of activities to businesses undertakings and regulated performances in the electricity sector.

Assessment of Cable Manufacturer Systems and Processes
Clients: Various; Global

Undertake an independent assessment of manufacturing systems and processes, including witnessing type tests.

Electrical Infrastructure Review
Clients: Various; Global

Undertake condition assessment surveys of existing HV electrical apparatus. Benchmark existing maintenance and support documentation against statutes and regulations.

Electrical Safety Rules and Competence Framework Development and/or Review
Clients: Various; Global

Develop/review electrical safety rules and associated competency frameworks, ensuring compliance with legislation and governing standards

Asset Management System Requirements for ISO 55000 Attainment
Clients: Various; Global

Provide consultancy support services to assist the customer for the development and implementation of a best practice asset management system in-line with ISO 55000.

References

Can be provided upon request

Global Footprint

We provide products, services and support for customers in 90 countries, through our offices in Australia, China, Europe, Singapore, UAE and USA, together with more than 40 distribution partners.



Our Expertise

We provide world-leading asset management solutions for power plant and networks.

Our customers include electricity generation, transmission and distribution companies, together with major power plant operators in the private and public sectors.

- Our products, services, management systems and knowledge enable customers to:
- Prevent outages
- Assess the condition of assets
- Understand why assets fail
- Optimise network operations
- Make smarter investment decisions
- Build smarter grids
- Achieve the latest standards
- Develop their power skills

RFP 2018-34
SCHEDULE A - STATEMENT of WORK

Background

Hydro Ottawa Limited (HOL) is continuously striving to achieve excellence with its Asset Management practices. With the introduction of the ISO 55000 Standard for Asset Management, HOL wants to ensure that it is following good industry practices by aligning its Asset Management practices with the intention of certifying in the future. HOL received an initial third party assessment in 2017 of its Asset Management practices with respect to compliance with the ISO 55001 standard. HOL has implemented numerous improvement measures and is looking to re-assess its current state.

The goal of this work is to assess HOL's current Asset Management practices, with regards to its distribution business, and provide a gap analysis and recommendations to align with the compliance requirements identified in the ISO 55000 standard.

Key Deliverables

(1) A detailed assessment of HOL's Asset Management practices as they relate to the requirements in the ISO 55000 standard. This will be specifically on HOL's distribution business and not companywide. Final report to include assessment scores against the 27 sections of ISO 55001.
(2) Gap analysis report of the findings from (1). Identification of high impact and priority areas for improvement as well as recommendations on actions/road blocks to close gaps (ex. specific document or process to be created).
(3) A presentation on the assessment (1) and gap analysis (2).

Out of Scope

(1) Assets out of scope of HOL's distribution business.
(2) A detailed roadmap identifying required resources and timelines as generally developed during assessments.

Proposal Requirements

1. Provide detailed proposed methods and cost breakdown on how deliverables will be met. Optional deliverables may be included, but separated out from key deliverables.
2. Overview of credentials and previous work in this area, specifically within electrical distribution industry.
3. Introduction to team members working on project.

Timelines

All deliverables must be completed by March 31, 2019.

Appendix III CVs



Profile

A Principal Consultant with a breadth of knowledge and experience in the electrical utility sector specialising in Asset Management and Overhead Lines. With a proven track record of managing businesses and projects, Andrew has the ability to deliver good quality work, on time, in scope and within budget.

Synopsis

- Andrew is a Principal Consultant who currently holds the position of Head of Asset Management and Power System Studies.
- He has over 40 years' experience in the electrical utility sector, since he started work as an apprentice electrician in the late seventies
- Andrew is a chartered engineer and a Fellow of the IET
- He joined EA Technology Ltd in 2011 from Line Design Ltd where he was the Managing Director, carrying out consultancy work that specialised in condition monitoring of overhead line assets.
- Andrew has vast experience of distribution Overhead Lines from a construction, operation, service provision and consultancy perspective.
- Andrew also has actively been involved in the assessment of many organisation's Asset Management Systems.
- Andrew has also been used as an expert witness, in a number of Wood Pole and Overhead Line related incidents that have resulted in serious or fatal injuries.

Qualifications and Memberships

- Chartered Engineer and Fellow of the Institution of Engineering and Technology (CEng, FIET)
- BSc Hons Computing and Design, Open University
- Certificate in Asset Management, The Institute of Asset Management
- Member of Institute of Asset Management (MIAM)
- Member of the British Standards AMS1 working group

Skills and Responsibilities

- Experienced Project Manager
- Experienced Asset Management Auditor
- ISO55000 Internal Auditor
- ISO 9001 Internal Auditor
- Detailed Knowledge of Overhead Lines
- Ex Senior Authorised Person (Overhead Lines)
- Vast experience in data collection and condition inspection of electrical assets.
- Detailed knowledge of wood pole testing and failure analysis.
- Good organisational skills having successfully started and run several successful businesses.

Career Summary

- 2011 to Present: EA Technology Ltd, Principal Consultant, Network Asset Management
- 2010 to 2011: Line Design Ltd, Managing Director
- 2001 to 2010: Poletecs Ltd, Managing Director/Operations Manager
- 1999 to 2002: Shomac Power Services Ltd, Managing Director
- 1978 to 1999: Manweb/Scottish Power, Electrician, Chargehand Linesman, Team Leader

Personal Interests

Passionate about furthering the discipline and general understanding of Asset Management.

Outside work Andrew enjoys travelling, classic cars and computer coding - he lives with his wife in North Wales.

Experience

Best Industry Practice Manual
Client: Solar Trade Association

Andrew was a contributing author of the STA's best practice manual on the management and mitigation of network outages for Distribution Network Operators (DNOs), and for solar farms connected to their networks.

ISO55000 Documentation
Client: Quintas Energy

Andrew assisted Quintas Energy's Asset Management staff create their Asset Management Policy, Asset Management System document and Strategic Asset Management Plan document.

ISO55000 Internal Audit
Client: Dhofar Power Company (DPC)

Andrew carried out an Internal Audit of DPC's Asset Management System and provided DPC with a list of findings that were evaluated in-line with their risk management process.

ISO55000 Internal Audit
Client: Guernsey Electricity

Andrew carried out an Internal Audit of Guernsey Electricity's Asset Management System and provided them with a list of findings that were evaluated in-line with their risk management process and incorporated within their risk reporting structure.

Incident Report Review
Client: Osbourne Clarke

Andrew carried out a review of an incident report that detailed an overhead line failure for one of Osbourne Clark's clients.

Asset Management System Implementation
Client: Guernsey Electricity

Andrew assisted Guernsey Electricity with the implementation of their Asset Management System from recommendations provided by a previous ISO55000 gap analysis. Andrew assisted with the creation, development and editing of Asset Management documentation, processes and organisational structure.

ISO55000 Gap Analysis
Client: Quintas Energy

Andrew carried out an ISO55000 gap analysis on Quintas Energy's Asset Management System. The gap analysis assessment tested the maturity of Quintas Energy's Asset Management System and provided guidance on how to become ISO55000 compliant.

Asset Management System Document
Client: Manx Utilities

Andrew assisted Manx Utilities develop an Asset Management System document for Manx Utilities that specified their Asset Management System.

ISO55000 Training and Document Review
Client: Foresight

Andrew provided a two-day ISO55000 training course and advised Foresight on

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Client: UK Power Networks

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Client: Health and Safety Executive

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Papers Published

'*JOURNEY FROM PAS 55 TO ISO 55000*', Co-Author, August 2015 for CIRED (Malaysia)

INTERROGATORY RESPONSE - SEC-57

2-SEC-57

EXHIBIT REFERENCE:

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

SUBJECT AREA: Reliability

Question:

Please update Tables 8 and 9 to include 2019 information. (Note: Please provide the response in excel format).

RESPONSE:

Please see excel Attachment SEC-57(A): Updated Tables 8 and 9 - SAIDI and SAIFI.

INTERROGATORY RESPONSE - SEC-58

2-SEC-58

EXHIBIT REFERENCE:

[Ex.2-4-3, Attachment G, p.8]

SUBJECT AREA: Distribution System Plan

Question:

Please provide a copy of the referenced documents:

a) Hydro Ottawa – *Strategic Direction*

b) Hydro Ottawa – IAS-0001 – *Asset Management Policy*

c) Hydro Ottawa – *Asset Management Plans*

d) Hydro Ottawa – *Project Evaluation Procedure*

e) Hydro Ottawa – *Project Prioritization Procedure*

RESPONSE:

Please see the following:

- Attachment SEC-58(A): 2016-2020 Strategic DIrection
- Attachment SEC-58(B): Hydro Ottawa Asset Management Policy
- Attachment SEC-58(C): Hydro Ottawa Asset Management Plans
- Attachment SEC-58(D): Hydro Ottawa Project Evaluation Procedure
- Attachment SEC-58(E): Hydro Ottawa Project Prioritization Procedure

Please note that Attachment SEC-58(C): Asset Management Plans has yet to be updated with 2019 values.

HydroOttawa

A leading partner in a smart energy future

Strategic Direction 2016-2020



Our Mission

To create long-term value for our shareholder, benefitting our customers and the communities we serve

Our Organizational Values

Teamwork, Integrity, Excellence and Service

Our Vision

Hydro Ottawa – a leading partner in a smart energy future

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1. Overview of Strategic Direction

1.1 INTRODUCTION

This 2016-2020 Strategic Direction provides an overview of Hydro Ottawa's business strategy and financial projections for the next five years. It is designed to inform our shareholder and all other stakeholders about the most important trends shaping our business environment, and how the company intends to respond to them.

Like those that preceded it – issued in 2008 and 2012 respectively – this Strategic Direction sets out a balanced program for strong performance in our existing operations, coupled with sustainable and profitable business growth. Our strategy is customer-centric, financially responsible, and responds to a strategic environment that has changed in important ways since the publication of our last Strategic Direction document.

The objectives outlined in Hydro Ottawa's 2012 Strategic Direction have largely been accomplished. Notably, the company has increased its renewable generation capacity several-fold during that period. From 22 megawatts at the beginning of 2012, our renewable generation capacity is now 79 megawatts (including joint ventures). The current expansion project at Chaudière Falls, scheduled for completion in 2017, and the purchase of Hydro Quebec's generation assets at Chaudière Falls, which we expect to complete in the coming months, would bring this total to 128 megawatts – enough clean, renewable energy to power 107,000 homes. Hydro Ottawa has also made important progress on enhancing customer value, operational effectiveness, and our contribution to the community.

Powered by strategic growth and positive performance in existing operations, Hydro Ottawa has exceeded the financial projections set out in our 2012 Strategic Direction each year. The company has also exceeded the stretch target of an additional $10 million in net income over the five-year period, having achieved an additional $16 million in net income, above annual targets, over the first four years of the plan.

These accomplishments, combined with the changes that have occurred in our business environment, mean that it is time to set new goals and refresh our strategy.

1.2 STRATEGY

Our stakeholders will find much that is familiar in this 2016-2020 Strategic Direction. It refreshes, rather than replaces, the corporate strategy outlined in the 2012-2016 Strategic Direction.

Our core mission and mandate remain the same: we will continue to create value for our shareholder, our customers and our community through excellence in the delivery of electricity and related services.

Likewise, our four Key Areas of Focus – the critical areas of performance that guide our planning and operations – remain the same: we will continue to focus on Customer Value, Financial Strength, Organizational Effectiveness, and Corporate Citizenship, with Customer Value continuing to be the central driver of business strategy. These Areas of Focus have stood the test of time and have driven our success to date.

Moreover, our business lines remain unchanged: they will continue to be electricity distribution, renewable energy generation, and energy and utility services.

However, we are operating in a strategic context that has evolved significantly since our last Strategic Direction. And Hydro Ottawa is a different company in important ways than it was in 2012, including the scale of its renewable generation business. In view of these realities, we have outlined a new Vision in this Strategic Direction – to be *a leading partner in a smart energy future*.

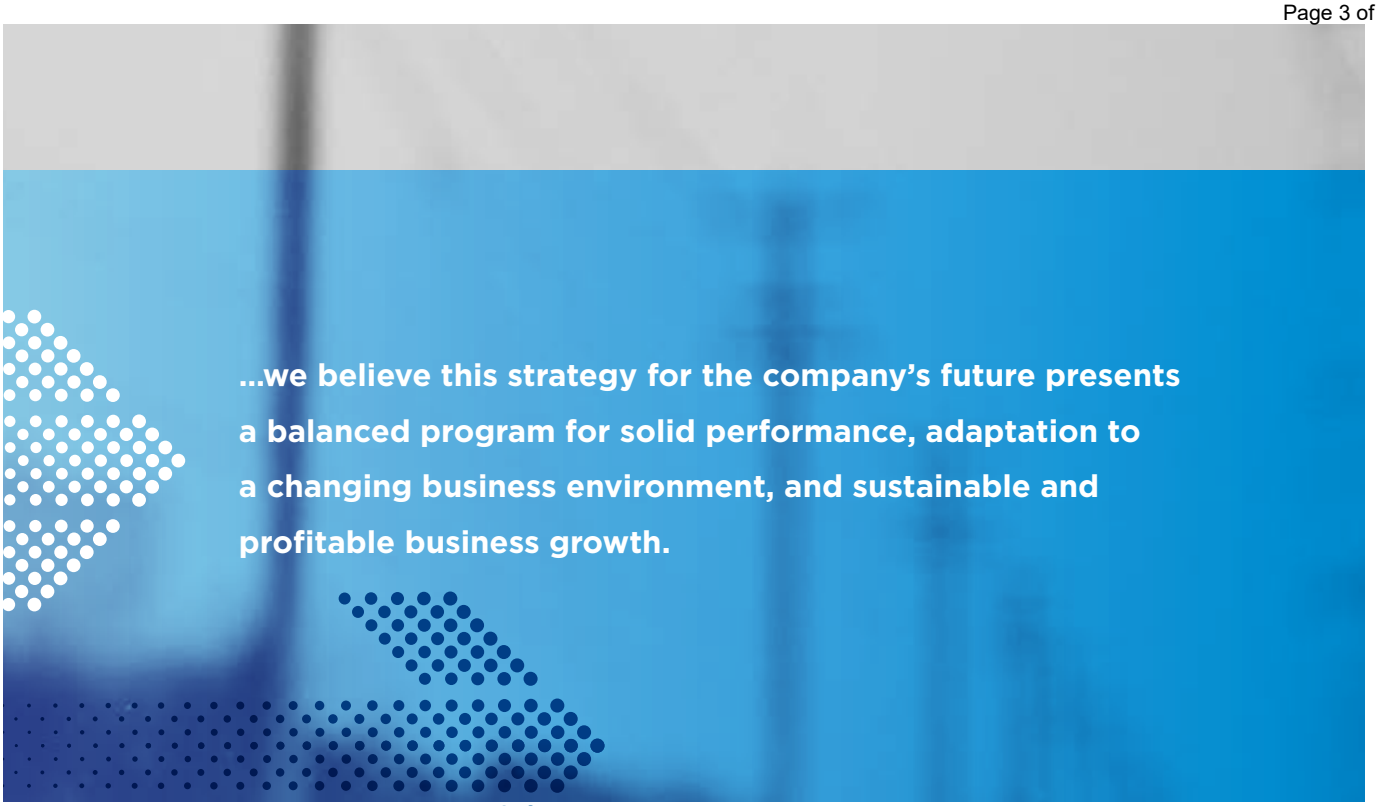


This Vision is described in detail in Section 4 of this Strategic Direction. In essence, it recognizes that the electricity service model is in the midst of significant transformation – taking on a more decentralized, customer-centric, technologically advanced and environmentally sustainable form – and the role of local electrical utilities will be transformed along with it.

Our strategy for responding to this emerging landscape involves:

- Taking customer experience to the next level;
- Continuing to achieve strategic growth, including continued growth in our renewable energy business, evaluating opportunities to grow our electricity distribution business, and expanding the range of services we provide;
- Ensuring access to capital for growth;
- Making sure we have the right skill sets and organizational capacity to deliver on existing and new business lines;
- Continuing to enhance operational performance, including productivity and safety;
- Delivering on critical projects such as the Chaudière expansion project;
- Continuing to build public confidence and trust; and
- Being ready to embrace change and disruption in our industry.

Our aim is to be the trusted energy advisor for our customers – large and small – and our community. We believe Hydro Ottawa's experience and core capabilities, and its position as a City-owned utility, make it uniquely suited to this role. As the energy needs and options of our customers and our community evolve, and as signature projects and developments proceed, Hydro Ottawa will play a leading role in helping our City to transition to a smart energy future.



We will also continue to grow shareholder value, maintaining a focus on strategic business growth within our core areas of strength. As noted above, Hydro Ottawa has significantly increased shareholder value through strategic growth over the past several years, particularly in our renewable generation business. As we continue to pursue this strategy, access to capital will be critically important. Among several approaches to meet this requirement, the company is seeking an amendment to its dividend policy. The amended policy would provide higher than historical dividends to our shareholder, while retaining some of the increased profits from growth within the company, to ensure we continue to enjoy access to capital on favourable terms and to safeguard our credit rating.

Taken as a whole, we believe this strategy for the company's future presents a balanced program for solid performance, adaptation to a changing business environment, and sustainable and profitable business growth.

1.3 FOUR STRATEGIC OBJECTIVES

Hydro Ottawa's success in the past has been achieved by focusing on four critical areas of performance – our four Key Areas of Focus. In each of these areas, we have set one overarching objective:

- **CUSTOMER VALUE:** We will deliver value across the entire customer experience;
- **FINANCIAL STRENGTH:** We will create sustainable growth in our business and our earnings;
- **ORGANIZATIONAL EFFECTIVENESS:** We will achieve performance excellence; and
- **CORPORATE CITIZENSHIP:** We will contribute to the well-being of the community.

These four areas of focus and strategic objectives will continue to guide our activities through the current plan. As in our previous Strategic Direction, the area of Customer Value takes on central importance.


Delivering
essential
services

2. Our Business

Hydro Ottawa Holding Inc., (Hydro Ottawa) is 100 percent owned by the City of Ottawa. It is a private company, registered under the Ontario *Business Corporations Act*, and overseen by an independent Board of Directors consisting of 11 members appointed by City Council. The core businesses of the Corporation are electricity distribution, renewable energy generation and related services. Hydro Ottawa owns and operates two subsidiary companies. In view of significant growth in the company's renewable generation portfolio, it is expected that other operating companies will be created during the course of this Strategic Direction, allowing for the separation of the energy services and renewable generation business lines currently housed within Energy Ottawa Inc.

Hydro Ottawa Limited

Hydro Ottawa Limited is a regulated electricity distribution company operating in the City of Ottawa and the Village of Casselman. As the third-largest municipally owned electrical utility in Ontario, Hydro Ottawa Limited maintains one of the safest, most reliable and cost-effective electricity distribution systems in the province, and serves over 324,000 residential and commercial customers across a service area of 1,100 square kilometres. As a condition of its distribution licence, the company is required to meet conservation and demand management targets established by the Ontario Energy Board. The company's customer base grows by an average of 1 percent per year.

Energy Ottawa Inc.

Energy Ottawa is the largest municipally owned producer of green power in Ontario, and a provider of commercial energy management services. It owns and operates six run-of-the-river hydroelectric generation plants at Chaudière Falls in Ottawa's core, and 10 additional run-of-the-river facilities in Ontario and upper New York State. Energy Ottawa also holds interests in two landfill gas-to-energy joint ventures that convert millions of tonnes of previously flared-off methane gas into renewable energy at the Trail Road landfill site in Ottawa and the Laflèche landfill site in Moose Creek, Ontario. In total, this represents a generation capacity of more than 79 megawatts annually, which is enough to power 62,000 homes. A multi-year project to expand Energy Ottawa's Ontario generation facilities at Chaudière Falls is under way, with completion scheduled for 2017, and a transaction for the purchase of Hydro Quebec's generating assets at Chaudière Falls is expected to close in the coming months. When both of these initiatives are complete, the company will have over 128 megawatts of installed green generation capacity.



Understanding the changing business environment

3. Strategic Context

3.1 BUSINESS ENVIRONMENT

If the words "electric utility" evoke a familiar image, it is because the basic business model of electricity service has not changed very much in the past 125 years. But that model is now in the midst of a significant shift – one that will ultimately make customers the most important players in the electricity market. This emerging reality of customer centrality is the most important driver of Hydro Ottawa's business strategy for the next five years and beyond.

The prototype for today's electricity system emerged in the wake of the "current wars" of the 1880s and '90s. Nikola Tesla's patents for alternating current technology (AC), backed by the industrial resources of George Westinghouse, allowed the cost-effective transmission of high voltage electricity over long distances starting in the 1880s. The resulting economies of scale proved too much for Thomas Edison's direct current (DC) technology to compete with, since Edison's system relied on small scale generation happening close to the consumer. When Edison's company joined with a major competitor to form General Electric in 1892, and embraced AC technology, the paradigm was set: large scale generation, high-voltage transmission over long distances, and then delivery to homes and businesses through local distribution networks, like the one operated by Hydro Ottawa. Power flowed in a single direction, without much involvement or control from the end user.

This model has served us well, but today, it is incapable of doing everything we need it to do. Transformation is well under way. It involves significant improvements to the centralized system of electricity supply, along with developments that would undoubtedly make Edison smile: increases in distributed generation, storage, and user control. If Edison and Westinghouse were alive today, they might well be business partners instead of arch rivals.

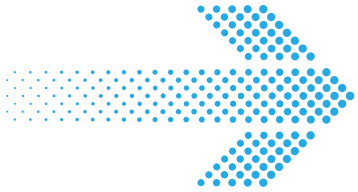
3.1.1 THE MAIN DRIVERS OF TRANSFORMATION

There are several reasons for the changes under way. The main drivers are cost, technology, and public policy and regulation relating to energy and related matters.

These three drivers of change are combining in ways that position customers to be much more active participants in the power system and the power market. Indeed, electricity consumers are poised to become the most influential actors in a new energy landscape – a dramatic break from the passive role consumers have traditionally played in electricity markets. This transformation to a more customer-driven and customer-centric model of electricity will present opportunities for energy providers that are able to innovate, and challenges for those that fail to adapt.

In terms of cost, the very scale of the centralized system makes it expensive to maintain. Electrical equipment is due for replacement at an unprecedented scale across Ontario and beyond, requiring massive and sustained capital investments. For Ontario local distribution networks alone, the Conference Board of Canada estimated that $21 billion would need to be invested between 2011 and 2030 to replace and refurbish aging infrastructure and facilitate smart grid developments, not to mention a further $60 billion for generation and $5.5 billion for transmission.

These cost factors, plus environmental concerns, have led to a greater focus on energy efficiency and conservation – for consumers, utilities, system operators, and policy makers. Indeed, Ontario has adopted a "Conservation First" approach to energy policy and planning, on the



premise that the cheapest kilowatt is the one that never has to be generated in the first place. According to Ontario's Long-Term Energy Plan (2013), conservation accounted for approximately 5 percent of Ontario's "energy supply" in 2013 (meaning 5 percent less generation was required), and this is projected to grow to 16% by 2032.

This focus on conservation, along with dramatic improvements in the efficiency of appliances such as TVs and refrigerators and the decline in mass production manufacturing across North America, means that electricity consumption has remained static. In Ottawa, average household consumption declined by about 7.5 percent between 2010 and 2014. As a result, despite continued growth in the number of connected customers, the volume of electricity delivered through Hydro Ottawa's distribution system dropped by 2.2 percent. This poses a challenge to the traditional utility business model based on a rate per kilowatt consumed by the customer.

At the same time, innovation is steadily reducing the cost of localized, or "distributed" generation (mainly renewables like solar and wind) and energy storage, such that they are expected to eventually be price competitive with centralized generation. Indeed, depending on the technology and the jurisdiction involved, this situation of "grid parity" may not be far off. The growing maturity and affordability of distributed energy technologies such as solar generation, storage, and geo-thermal heating is expected to reshape the energy supply landscape. Customers will increasingly produce a portion of the energy they need on site, or become sellers of energy as well as consumers.

A similar trend can be seen with electric vehicles (EVs), where innovation is steadily bringing down costs. While market penetration is currently low, consumer interest is very high, and EV sales are likely to grow exponentially as costs decline.

Coinciding with these technological advances is the policy imperative of reducing carbon emissions in response to the threat of climate change. This reinforces interest in renewables both at the micro scale and the utility scale, and the electrification of transportation through EVs. Investors are responding at an unprecedented level. Globally in 2015, they invested $285.9 billion in renewable generation (excluding large hydro-electric dams) – more than double the amount invested in new coal or gas generation.

Another technological trend transforming the utility paradigm is the emergence of the Smart Grid through the convergence of information technology with grid technologies. The ability to see what is happening in the grid, apply sophisticated data analytics, and respond remotely without sending utility trucks has already reshaped utility control rooms. Next, the sharing of grid information and control with customers, and the ability to use data and analytics to provide personalized service, will transform the consumer's relationship with the power system.

The role of information technology in transforming the utility landscape cannot be overstated. It has transformed customer service approaches across many industries, and the electricity sector will be no exception. The opportunities for customized service and consumer control are growing daily, as are customer expectations for choice, convenience and responsiveness, informed by their experience with other industries. The ability to access information and complete transactions "anywhere, anytime" through mobile technology is increasingly a baseline expectation.

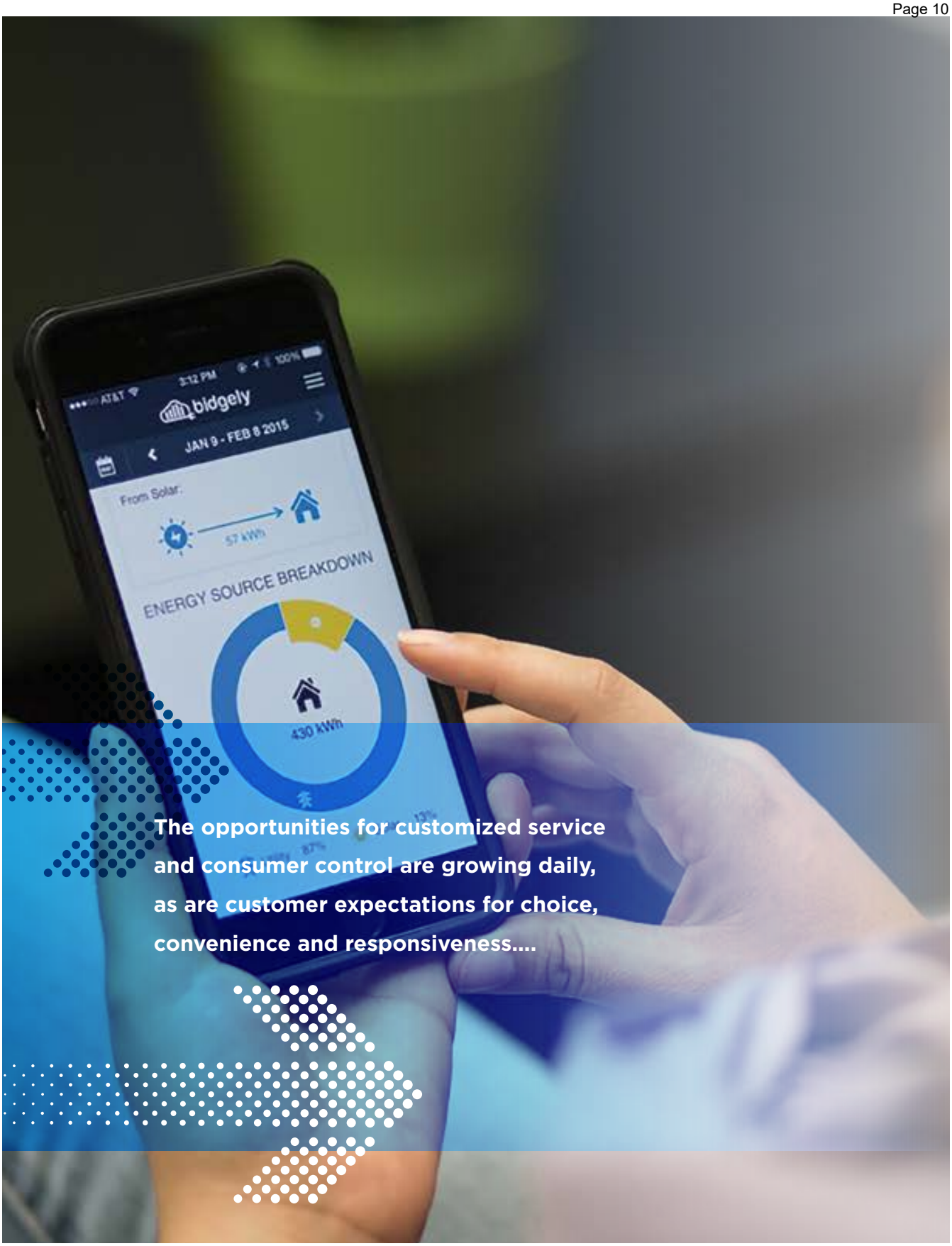
Equally important, it is not just customers who are connected everywhere and all the time; increasingly, so are their homes, appliances, equipment and vehicles through the emerging internet of things. While utilities will continue to manage the grid, Smart Grid technologies and the internet of things will "connect the customer to the control room", giving them a much bigger role. The consumer's home, office, store, farm, or factory is becoming an integral part of the power system, and their laptops or mobile devices are becoming interconnected with the system control room.

The internet of things has broad implications for the electricity industry. It is likely to result in significant product innovation, game-changing partnerships, and converging markets, as both new and existing market participants seek to enable customers to harness its potential for efficiency, revenue generation, convenience, control and environmental performance. In essence, it creates a new "digital ecosystem" for energy to which utilities will have to adapt. It opens the door for energy market participants that exist purely in the digital space – a scenario that has led to creative disruption in many other industries, from movie rentals to transportation to hotel accommodation and many more. In the electricity industry, it is likely that the market for "behind the meter" products and services will increase as a proportion of the total energy dollar.

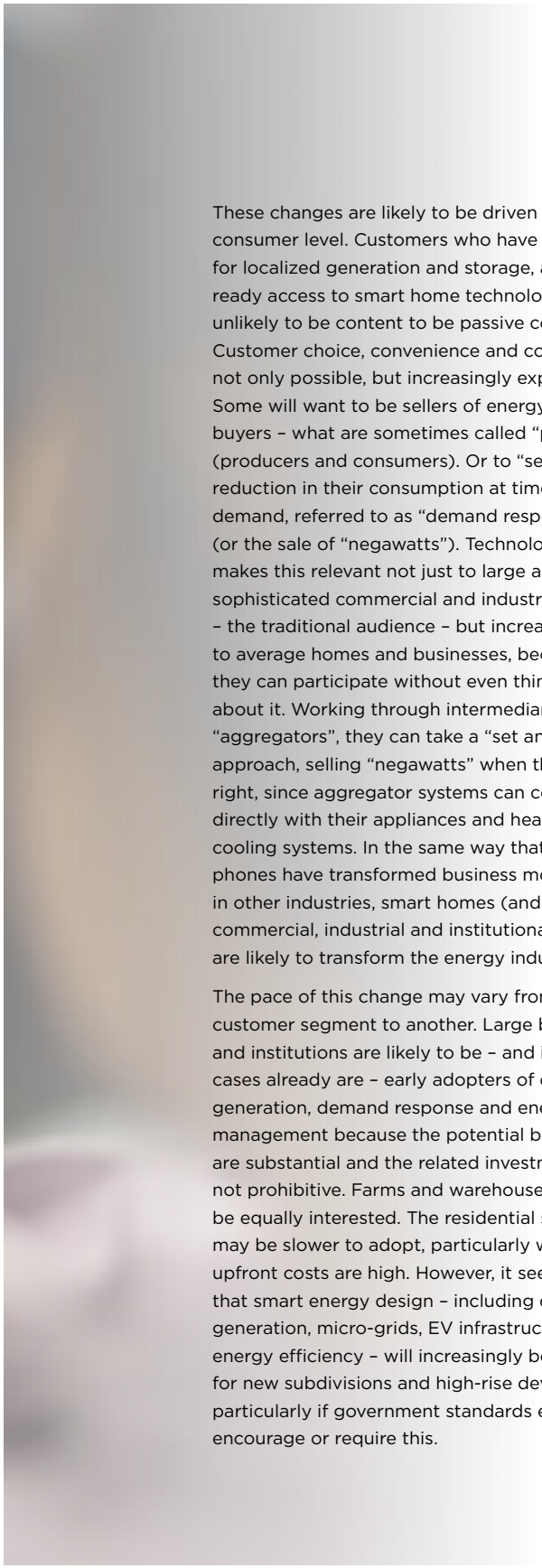
At Hydro Ottawa, we've been preparing for these changes for a number of years. Our two previous multi-year Strategic Direction documents both placed significant emphasis on modernization and preparation for change, from a technological, customer service, and business model perspective. This Strategic Direction is squarely in the same vein, building upon those that preceded it to embrace change in our industry. We believe local electrical utilities will be more relevant than ever in this new landscape, but their role will change, along with those of every other player in the system – consumers, system operators, generators, transmission utilities, and regulators included.

The transformation to a more customer-driven and customer-centric model of electricity will present opportunities for energy providers that are able to innovate....





The opportunities for customized service and consumer control are growing daily, as are customer expectations for choice, convenience and responsiveness....



These changes are likely to be driven at the consumer level. Customers who have options for localized generation and storage, and ready access to smart home technology, are unlikely to be content to be passive consumers. Customer choice, convenience and control are not only possible, but increasingly expected. Some will want to be sellers of energy, not just buyers – what are sometimes called "prosumers" (producers and consumers). Or to "sell" a reduction in their consumption at times of peak demand, referred to as "demand response" (or the sale of "negawatts"). Technology makes this relevant not just to large and sophisticated commercial and industrial facilities – the traditional audience – but increasingly to average homes and businesses, because they can participate without even thinking about it. Working through intermediaries called "aggregators", they can take a "set and forget" approach, selling "negawatts" when the price is right, since aggregator systems can communicate directly with their appliances and heating and cooling systems. In the same way that smart phones have transformed business models in other industries, smart homes (and smart commercial, industrial and institutional facilities) are likely to transform the energy industry.

The pace of this change may vary from one customer segment to another. Large businesses and institutions are likely to be – and in some cases already are – early adopters of distributed generation, demand response and energy management because the potential benefits are substantial and the related investments are not prohibitive. Farms and warehouses may be equally interested. The residential segment may be slower to adopt, particularly where the upfront costs are high. However, it seems likely that smart energy design – including distributed generation, micro-grids, EV infrastructure and energy efficiency – will increasingly be a focus for new subdivisions and high-rise developments, particularly if government standards emerge that encourage or require this.

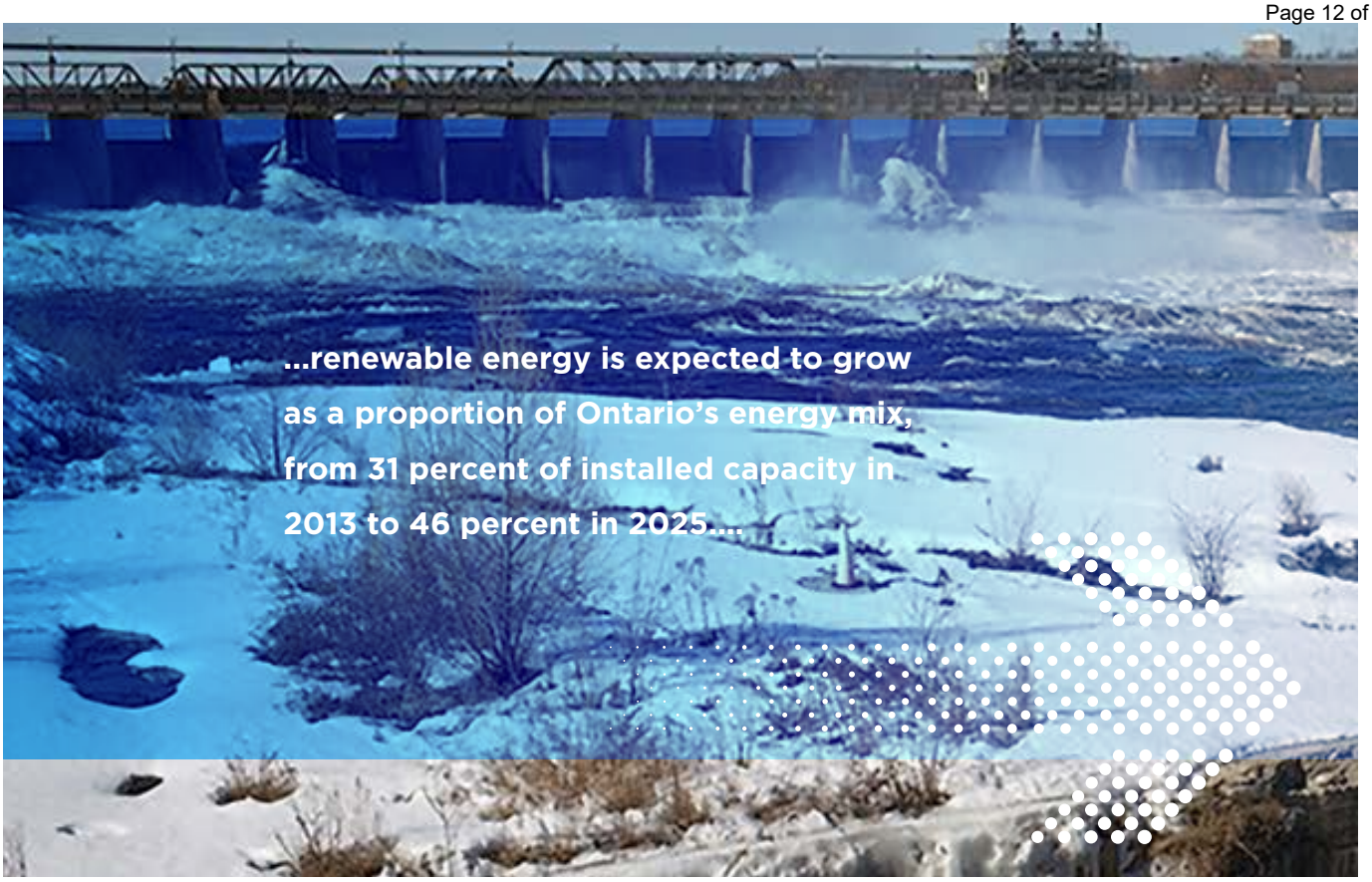
3.1.2 THE OPPORTUNITIES RESULTING FROM TRANSFORMATION

The impacts of the changes described above depend on where one is located in the energy ecosystem. Of all electricity sector participants, local distribution companies are closest to the customer, and will be directly affected by the shift to customer centrality. They will see new opportunities, as well as a need for transformation in the way they do business.

A key enabler for many of developments described in the preceding section – from demand response markets to the integration of more distributed generation and widespread use of EV's – will be a reliable – and smart – local electricity distribution network. One that allows power to flow in both directions, and responds effectively to fluctuations in supply and demand, coupled with sophisticated back office functionality capable of handling complex transactions.

More broadly, there are opportunities to leverage the modernization of electricity infrastructure and services to create not just a Smart Grid, but smart communities and a smart city. Landmark developments and municipal projects proposed or under way in Ottawa – such as light rail transit, the redevelopment of Lebreton Flats, and the transformation of the Chaudière Falls district – will change the face of the nation's Capital in important ways. If properly leveraged through collaboration, these signature projects can have an even more transformative impact. Hydro Ottawa – as a municipally-owned and community-minded company – will seek opportunities to collaborate on innovative energy solutions for our community, becoming a leading partner in a smart energy future.

The shift toward renewable energy driven by improving technology and concerns over climate change also presents an opportunity for utilities with expertise in this area. According to Bloomberg New Energy Finance, global clean energy investment has grown almost six-fold since 2004, and reached record levels in 2015.



The UN Environment Programme reports that renewable energy (excluding large hydro) made up the majority of gigawatts of new generating capacity installed in 2015 for the first time ever, at 53.6%. These trends are evident in Ontario, where renewable energy is expected to grow as a proportion of Ontario's energy mix, from 31 percent of installed capacity in 2013 to 46 percent in 2025 (including large hydro), and from 44 terawatt hours of production to 68 terawatt hours by 2025.

Hydroelectricity, which represents the bulk of Hydro Ottawa's renewable energy production, plays an important role in Ontario's Long Term Energy Plan (2013). More than half of Ontario's current renewable energy supply, and over 20 percent of the province's electricity supply overall, comes from hydroelectric facilities. Generation from this source is expected to grow to 42.2 terawatt hours by 2025 – a 19 percent increase over 2013 levels.

In addition to the indispensable role of local distribution utilities in providing the Smart Grid, and the opportunities associated with utility-scale renewables, there will also be new opportunities for utilities that are able to anticipate and meet the changing needs and expectations of customers for energy-related services. As the range of customer options for energy expands, so will the market for services that help them to generate, sell, store, manage and conserve energy, and reduce their costs and greenhouse gas emissions.

The customer proximity, assets and expertise of local distribution utilities mean they are uniquely well-placed to transform the last mile of the 125-year-old model, serving as the interface between customers and the new energy system, and proactively seeking opportunities to accelerate the adoption of smart energy technologies. Many customers see their local utilities as the preferred partner in value-added energy services. This "trust advantage" presents opportunities for an expanding range

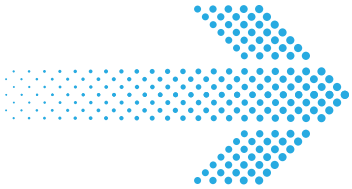


of services, and makes utilities an ideal strategic partner for other market participants who offer innovative energy solutions, but enjoy lower brand recognition and consumer trust. Consumer interest in small-scale renewables and energy storage is strong and growing, and utilities are well-placed to offer these options to their customers through new service offerings. Given the opportunity to work with a trusted partner such as their local utility, many more homes and businesses may choose to become producers of energy as well as consumers. EV infrastructure is another emerging customer need that utilities are well-positioned to meet.

3.1.3 KNOWING THE CUSTOMER AND RESPONDING TO THEIR NEEDS

Customer centrality represents the single most important change in the fundamentals of the utilities business. It has been the key driver of Hydro Ottawa's business strategy over the past several years, and will continue to be our focus over the next five years. The customer value we provide "up to and beyond the meter" will drive our financial strength and business growth, our operational efficiency and effectiveness, and our contributions to the well-being of our community.

As the customer's place within the electricity system evolves, successful utilities will be those that recognize that customers are not all the same, and adapt and tailor their service delivery to the specific needs of individual customers, leveraging technology to enhance the customer experience and increase operational agility. The tools exist for utilities to understand and engage their customers at an individual level, and provide truly personalized service. Leveraging the power of big data, the capabilities of the Smart Grid and the convenience of mobile technology, utilities can anticipate and meet customer needs with increasing precision, offer service "anytime, anywhere", and create a more effortless customer experience. A willingness to invest in the skills, culture, technology and practices needed to leverage those tools will be a key difference between leading and trailing utilities in a more customer-centric landscape.



3.2 POLICY AND REGULATORY ENVIRONMENT

Policy and regulatory responses to a range of issues can have a significant impact on our business environment. Containing rising electricity rates while facilitating much-needed infrastructure and technology investments is a key challenge facing regulators and policy makers, as is the need to limit and respond to climate change.

3.2.1 CONSOLIDATION

One response to electricity cost concerns has been to encourage utility consolidation to achieve economies of scale. In 1996, there were 307 municipal electrical utilities (MEUs) serving Ontario customers. Today there are 73. Hydro Ottawa itself resulted from the amalgamation of five MEUs at the time of the City's amalgamation. This number will continue to drop, as mergers and acquisitions within the sector continue to be pursued. Consolidation has been a policy recommendation of many panels and commissions, including the Advisory Committee on Competition in Ontario's Electricity System in 1996 (the "Macdonald Committee"), the Ontario Distribution Sector Review Panel in 2012 (the "Elston Panel"), the Commission on the Reform of Ontario's Public Services, also in 2012 (the "Drummond Report"), and the Premier's Advisory Council on Government Assets that reported in 2015 (the "Ed Clark Report").

Three recent developments make the issue of consolidation particularly relevant at the present time. First, three MEUs in the Greater Toronto Area and Hamilton have proposed to merge (Enersource Corporation, PowerStream Inc. and Horizon Utilities Corporation) and to acquire Hydro One Brampton Inc. from the province of Ontario. This merger – which must still secure regulatory approval – would create Ontario's largest MEU, serving nearly a million customers. Second, the province recently divested 15 percent of its interest in Hydro One through an initial public offering (IPO), and has plans for up to three more share offerings, divesting up to 60 percent of its interest in total. In parallel with this IPO, Hydro One has pursued acquisitions of certain MEUs, and further expansion efforts can likely be expected. Third, in order to encourage consolidation, the province has exempted utilities from paying capital gains tax on utility dispositions from January 1, 2016 to December 31, 2018, and provided partial relief from the electricity transfer tax that applies to sales of utility assets to the private sector. These developments will likely increase the momentum toward consolidation in the sector, and more mergers and acquisitions can likely be expected. For example, three MEUs operating east and north of Toronto – Veridian Corporation, Oshawa Power and Utilities Corporation and Whitby Hydro Energy Corporation – recently announced that they have signed a memorandum of understanding to explore the benefits and feasibility of a merger.

Hydro Ottawa's main focus with respect to consolidation has been the acquisition of Hydro One customers within the City of Ottawa, to complete the consolidation of electricity services that was left incomplete at the time of municipal amalgamation. However, within the current regulatory framework, a commercially viable transaction to acquire these customers has not been possible, and discussions with Hydro One were discontinued in 2015. Consolidation with other Eastern Ontario utilities outside of Ottawa could also potentially benefit customers and our shareholder, and Hydro Ottawa remains open to considering such opportunities.

Fiscal pressures faced by the Province of Ontario have also prompted a rationalization of the regulatory framework, including a reduction in the number of regulatory agencies, in particular through the merger of the Ontario Power Authority with the Independent Electricity System Operator (IESO).



3.2.2 PERMITTED BUSINESS ACTIVITIES

There has also been a growing recognition that meeting the above policy objectives, and responding to changing customer needs and expectations, will require utilities to adopt new business models. It is no longer realistic to regard distribution, generation and energy management as distinct and isolated activities and barriers to utility collaboration across service territories may prevent efficiencies that could be achieved through means other than mergers or acquisitions. To that end, amendments to the *Ontario Energy Board Act* that were adopted in 2015 (through Bill 112) have removed certain restrictions on the business activities of local distribution company affiliates, and relaxed restrictions on the activities of distributors themselves. This will afford opportunities to achieve efficiencies, develop new revenue streams, and provide seamless energy-related offerings to customers.

In view of these developments, it seems likely that utility revenues will in future be made up of a greater mix of regulated distribution service charges and new revenue streams that result from leveraging the utility's core competencies to provide value-added services. The customers for these services may be within or outside of the distributor's traditional service territory, and in some cases may be other utilities. The continued push to transition to renewable energy sources also represents a continued revenue opportunity for utilities that have a core strength in this area, such as Hydro Ottawa.

3.2.3 RATE STRUCTURES

In parallel, the Ontario Energy Board has directed electricity distributors, including Hydro Ottawa, to transition to a fixed-charge approach to distribution service charges over the next four years. This reflects the centrality of the local distribution system to energy modernization,

and is aimed at providing adequate resources to maintain it regardless of consumption levels. At the same time, revenue growth from distribution charges is expected to be modest due to an emphasis on cost control at the policy, regulatory, and utility levels.

3.2.4 CLIMATE CHANGE

Beyond economic and cost considerations, the policy and regulatory landscape for electricity is and will continue to be profoundly shaped by the policy objective of reducing greenhouse gas emissions (GHGs) to limit climate change. Ontario has announced that it will implement a cap-and-trade program to reduce GHGs to 15 per cent below 1990 levels by 2020 and 80 per cent below 1990 levels by 2050. The federal government has strongly signalled that a national initiative to put a price on carbon will be forthcoming, though the shape of that program and its relationship to provincial initiatives remains to be seen. Electricity can be a very low-carbon energy source, and is therefore well-placed to be part of the solution, but improved efficiency and changes in supply mix will undoubtedly be required. This means the policy focus on renewable energy, energy conservation and demand response can be expected to continue and intensify. In addition, utilities can expect increasing demands to reduce the carbon intensity of their own operations. The same will be true of other businesses and institutions, which could increase demand for energy services that Hydro Ottawa is well-placed to provide.

3.2.5 RENEWABLE ENERGY

Ontario's approach to the procurement of renewable energy continues to evolve. In general, it has become more competitive. Micro-scale renewable projects (10 kilowatts and under) continue to be accepted for premium pricing under the micro-FIT program (or micro-Feed-in-Tariff), up to an annual cap, which in 2015 was 50 megawatts. Projects of between 10 and 500 kilowatts can bid into the FIT program (FIT 4) during defined application periods. In 2015, the program accepted applications for three weeks in October, and received applications representing 2.4 times the capacity to be awarded. Prices offered under these programs (FIT 4 and micro-FIT) are reviewed annually. It is possible that they could evolve from premium-price procurement programs into a net metering program (with power being used by the home or business and only the excess being sold into the grid) as the cost of small-scale renewables continues to decline. Power-purchase agreements for larger-scale renewables (more than 500 kilowatts) are awarded through the Large Renewable Procurement (LRP) program, which involves highly competitive procurement rounds conducted by the IESO. In some cases, the Minister of Energy has also directed the IESO to enter into negotiations for a power purchase agreement relating to a specific facility in order to achieve energy policy objectives.



3.2.6 CONSERVATION AND DEMAND RESPONSE

Provincial energy policy continues to emphasize conservation under a "Conservation First" approach to energy planning. Under this framework, the province is committed to investing in conservation first, before new generation, where this is a cost-effective solution.

Conservation is aimed at reducing the volume of electricity consumed over a period of time (for example, a month or a year). Demand reduction, also called demand response, is a complementary effort aimed at reducing the quantity of energy required at any one point in time – specifically, at times of peak demand. Time-of-use rates present one means of achieving this; another is to pay customers to reduce consumption when demand is highest. The IESO recently completed its first demand response (DR) auction – a mechanism to pay for demand reduction ("negawatts") rather than purchasing additional power ("megawatts") at times of peak demand – and has stated that it will eventually shift the procurement of DR resources from contracts to a market-based mechanism that is more flexible and cost-effective for ratepayers. For now, auctions will occur on an annual basis, but in the future DR resources may bid into the spot market alongside generators and imports.



Demand response is currently projected to account for 5 percent (or 2,242 megawatts) of Ontario's electricity supply capability by 2025, but recent developments in the United States suggest demand response may come more quickly, and on a larger scale, than many have anticipated. The Federal Energy Regulatory Commission (FERC) issued Order 745 instructing market operators in the US (similar to Ontario's IESO) to allow demand response ("negawatts") to bid into the electricity market on the same terms as generation ("megawatts"). This Order was originally quashed by a court on the grounds that FERC did not have jurisdiction to issue it, but that decision has recently been overturned by the US Supreme Court. It is expected that this decision will result in a significant growth in the demand response market in the US. Navigant Research projects that the global market for demand response will grow from just 31 gigawatts in 2014 to about 197 gigawatts by 2023 – an increase of more than 500 percent – with revenues growing from $1.6 billion to $9.7 billion. Given the highly integrated nature of North American power markets, and the stated interest of the IESO in this type of approach, it seems likely that a dramatic upscaling of demand response in the US would eventually translate into greater adoption in Ontario as well. While DR has not been a significant factor in Ottawa to date, due to the absence of a large industrial base, it could become more relevant when and if a significant market develops for aggregated residential and commercial demand response.

3.2.7 CYBER SECURITY

There is broad recognition among governments, regulators and utilities that critical infrastructure such as electricity distribution grids could become the target of cyber security threats, including intentional targeting by terrorists, organized crime and foreign entities. The consequences of such targeting could be severe. The federal government, working with partners from a range of sectors, developed a *National Strategy for Critical Infrastructure* and a corresponding *Action Plan for Critical Infrastructure*. The Action Plan has been



refreshed for the 2014-2017 period, and provides a framework for a coordinated response among federal, provincial, territorial and critical infrastructure sector partners to strengthen critical infrastructure resilience. The new Minister of Public Safety and Emergency Preparedness has been mandated to conduct a review of existing measures to protect Canadians and our critical infrastructure from cyber-threats. Hydro Ottawa and other electric utilities collaborate on cyber security issues, including information sharing and input into federal and other policy initiatives, through the Canadian Electricity Association's Security and Infrastructure Protection Committee (SIP). SIP has regular discussions with federal security and intelligence agencies. Within the electricity industry, there is also coordination and mandatory reporting of cyber security information through the North American Electric Reliability Corporation (NERC). The IESO operates a Cyber Security Forum to facilitate collaboration within the Ontario industry.

3.2.8 CONCLUSION

These areas of policy and regulation are evolving. The speed of this change and direction it takes will have a significant impact on Hydro Ottawa's business strategy and success. The organization is well positioned to provide services to other utilities, to develop new revenue streams based on value-added services, to continue to grow its renewable generation business, and to pursue mergers and acquisitions. As described below, our vision is to be a leading partner in a smart energy future, and the company is well-placed to embrace that role.




Ensuring
a more
sustainable
energy future

4. Strategic Direction

4.1 OUR MISSION

To create long-term value for our shareholder, benefitting our customers and the communities we serve.

Hydro Ottawa is both a community asset and an investment for our shareholder, the City of Ottawa. As a community asset, our purpose is to provide efficient and reliable services and a first class customer experience to our customers, and to continue to be a strong strategic partner with the City, helping to deliver on its economic development and environmental agendas. As an investment, our purpose is to provide stable, reliable and growing returns, and to increase shareholder value both in the short- and long-term.

4.2 OUR GUIDING PRINCIPLES

Hydro Ottawa is committed to creating long-term value in a manner that will withstand the test of public scrutiny and inspire confidence and trust. To that end, we strive to achieve excellent operating and financial results while abiding by professional standards of conduct. We are guided not only by legal obligations, but also by best governance and business practices, and standards established by independent agencies. These expectations provide the foundation for our commitment to all of our stakeholders, and are reflected in our organizational values, our *Code of Business Conduct*, and our operating policies and procedures.

4.2.1 OUR ORGANIZATIONAL VALUES

At Hydro Ottawa we are committed to an organizational environment that fosters and demonstrates ethical business conduct at all levels and reflects our shared values of teamwork, integrity, excellence and service. Every employee must lead by example in this endeavour.

4.2.2 OUR COMMITMENTS TO OUR STAKEHOLDERS

Hydro Ottawa takes into account the interests of all our stakeholders including employees, customers, suppliers, our shareholder and the communities and environment in which we operate.

Employees

The quality of our workforce is our strength and we will strive to hire and retain the best-qualified people available and maximize their opportunities for success. We are committed to maintaining a safe, secure and healthy work environment enriched by diversity and characterized by open communication, trust, and fair treatment.

Customers

Our continued success depends on the quality of our customer interactions, and we are committed to delivering value across the entire customer experience. We are honest and fair in our relationships with our customers, and provide reliable, responsive and innovative products and services in compliance with legislated rights and standards for access, safety, health and environmental protection.

Suppliers and Contractors

We are honest and fair in our relationships with our suppliers and contractors and purchase equipment, supplies and services on the basis of merit, with a preference for local procurement. We pay suppliers and contractors in accordance with agreed terms, encourage them to adopt responsible business practices, and require them to adhere to our health, safety and environment standards when working for Hydro Ottawa.

Community and the Environment

We are committed to being a responsible corporate citizen and will contribute to making the communities in which we operate better places to live and do business. We are sensitive to the community's needs, and dedicated to protecting and preserving the environment where we operate.

Shareholder and Other Suppliers of Finance

We are financially accountable to our shareholder and to the institutions that underwrite our operations, and communicate to them all matters material to our organization. We protect our shareholder's investment, and manage risks effectively. We communicate to our shareholder all matters that are material to an understanding of our corporate governance.

Hydro Ottawa takes into account the interests of all our stakeholders including employees, customers, suppliers, our shareholder and the communities and environment in which we operate.



4.3 OUR VISION AND STRATEGY

4.3.1 OUR VISION

Hydro Ottawa – a leading partner in a smart energy future.

Leading...

For Hydro Ottawa, leading means consistently being among the top performers in the business, in every critical area of our operations; and being regarded as a credible and trusted voice in our industry, helping to shape policy, regulatory and operational responses to the critical issues of the day.

Leading means not merely reacting effectively to the transforming utility landscape, but proactively seeking opportunities to accelerate the adoption of smart energy solutions. We want our customers and our community to have the benefits this can provide, and we think local utilities have a critical role to play in making these solutions a reality.

To ensure we're leading, we will continue to recruit and fully leverage the talents of great people, listen to innovators and stakeholders in our community, partner with educational institutions, and work closely with other leading companies to keep abreast of new developments and help drive innovation.

Partner...

Utilities such as Hydro Ottawa will play a critical role in building a smart energy future; but we're not the only essential players. Indeed, as noted earlier, the fundamental change under way in the electricity sector is that customers are becoming the most important players in the electricity market. The transition to a smart energy future will be driven by consumers' needs, preferences, and objectives.

At the same time, with their local utility as a proactive and innovative partner, customers and communities can reach these goals faster, more efficiently, and to a much greater extent. The customer is at the centre of our business, and our aim is to be their trusted advisor and energy partner.

As a City of Ottawa-owned company, we are equally committed to the well-being of our community. We will continue to be a strong partner with our shareholder, helping to deliver on its energy, economic development, and environmental agendas, and will look for ways to enhance that partnership even further.

Partnership means working together, in ways that may be familiar or new. Hydro Ottawa is committed to working collaboratively to find smart solutions to evolving energy needs.

That means re-examining our work methods, being flexible, entrepreneurial, and open to new possibilities, and developing innovative products and services.

This may mean partnering on new types of projects – microgrids, smart communities, district energy, and more. Where the business case is viable, Hydro Ottawa will embrace new approaches. It may also mean collaborating with new, unconventional and even disruptive players in the energy landscape. For example, as smart home technology and the internet of things start to take shape, the world's biggest technology companies are being attracted to the energy domain. This may present opportunities for partnerships that will enhance the customer experience.

...in a Smart Energy Future

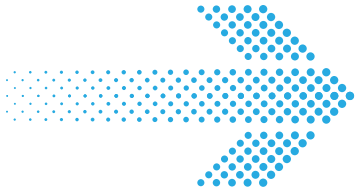
There are lots of descriptions of what "smart energy" looks like. What we mean when we use the term is an energy system that makes effective use of available technologies to maximize consumer, community and environmental benefit. By definition, then, it is sustainable, customer-centric, reliable, cost-effective, secure, and constantly evolving. It is responsive to evolving needs and opportunities, and focused on tangible benefit.

This provides a standard for assessing progress toward our vision: how sustainable, customer-centric, reliable, cost-effective, secure, and responsive is the energy system we are helping to create? But there is also an intuitive element to the concept of "smart energy", and the whole is greater than the sum of its parts. Like a smart phone or a smart home, we know smart energy when we see it, and we know it will look different tomorrow than it does today, as technology and consumer needs evolve. Smart energy is also a foundational component of a smart city, and Hydro Ottawa will welcome opportunities to collaborate in the pursuit of that objective.

By developing a smarter electricity grid that improves efficiency, customer control and reliability, by generating more clean and renewable electricity, and by partnering with our customers, our community, and other utilities on innovative energy solutions, we will be contributing to a smart energy future. If we do this to a standard of excellence, Hydro Ottawa will be a leading partner in that future, which is exactly what we aim to achieve.







4.3.2 OUR STRATEGY

The essence of Hydro Ottawa's strategy is to put the customer at the centre of everything we do. Reorienting our business around the customer was the primary goal of our previous Strategic Direction, and customer centrality continues to drive our business strategy. We believe that a sharp focus on the value we provide to our customers will generate positive results in all areas of performance – our financial strength and business growth, our operational efficiency and effectiveness, and our contributions to the well-being of our community.

As described earlier, the electricity service model is in the midst of significant transformation – taking on a more decentralized, customer-centric, technologically advanced and environmentally sustainable form. The transition to a more customer-driven and customer-centric model of electricity will present opportunities for energy providers that are able to innovate, and challenges for those that fail to adapt. Our strategy for responding to this emerging landscape involves:

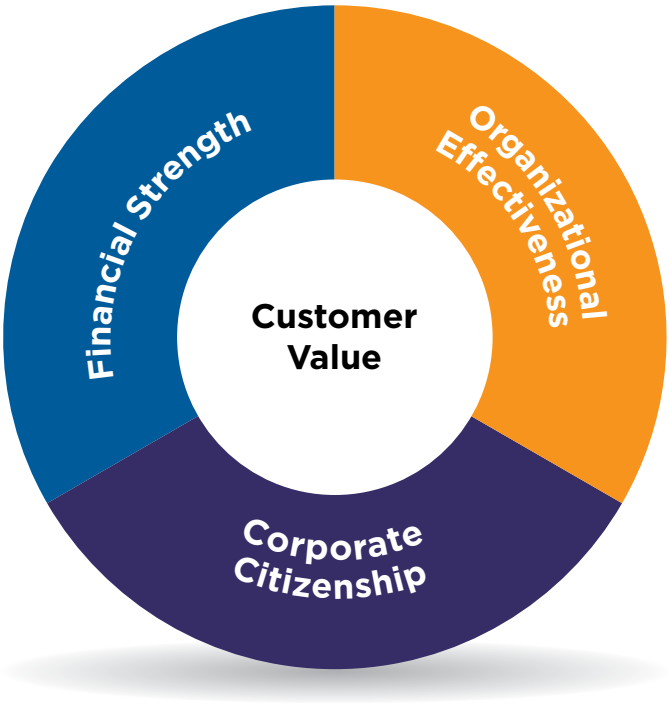
- Taking customer experience to the next level;
- Continuing to achieve strategic growth;
- Ensuring access to capital for growth;
- Making sure we have the right skill sets and organizational capacity to deliver on existing and new business lines;
- Continuing to enhance operational performance, including productivity and safety;
- Delivering on critical projects such as the Chaudière expansion project;
- Continuing to build public confidence and trust; and
- Being ready to embrace change and disruption in our industry.

To ensure we have the scale, financial capacity, and culture of innovation necessary to respond to evolving customer needs and expectations, and to achieve sustainable growth in shareholder value, our strategy includes a continued focus on strategic business growth within our core areas of strength. Our growth agenda involves four basic components:

- **Electricity Distribution:** continuing to evaluate opportunities to increase our distribution service territory;
- **Renewable Generation:** increasing the supply of clean energy for customers and earnings for our shareholder by making smart investments in renewable generation;
- **Energy Services:** providing innovative solutions to help consumers, businesses and communities meet their energy objectives, through energy management, conservation, efficient streetlighting, energy generation, energy storage, district energy, and demand response opportunities, among others; and
- **Utility Services:** leveraging our assets and expertise to help other utilities to enhance the value they provide, creating new revenue streams and economies of scale.

To keep us on course in achieving our strategy, this Strategic Direction is structured around four critical areas of performance that have stood the test of time and driven our success to date – our four Key Areas of Focus. They will guide our activities throughout the current plan as well, with Customer Value continuing to be the central driver of business strategy.

4.4 DELIVERING ON OUR VISION – FOUR KEY AREAS OF FOCUS



CUSTOMER VALUE

We will deliver value across the entire customer experience

> by providing reliable, responsive and innovative services at competitive rates

FINANCIAL STRENGTH

We will create sustainable growth in our business and our earnings

> by improving productivity and pursuing business growth opportunities that leverage our strengths – our core capabilities, our assets and our people

CORPORATE CITIZENSHIP

We will contribute to the well-being of the community

> by acting at all times as a responsible and engaged corporate citizen

ORGANIZATIONAL EFFECTIVENESS

We will achieve performance excellence

> by cultivating a culture of innovation and continuous improvement

4.4.1 CUSTOMER VALUE

As a company that provides an essential service to the public, nothing is more critical to Hydro Ottawa's success than the ability to deliver value to our customers. This is truer today than ever, as customers take on a more prominent role in shaping the electricity landscape.

The fundamentals of customer value in the electricity business have long been considered to be quality and cost – delivering a reliable service, while operating efficiently and effectively to keep rates competitive. Our commitment to these objectives has never been stronger. Over the course of this plan, Hydro Ottawa will invest a projected $535 million to replace aging infrastructure and enhance service reliability for our customers. And we will continue to enhance our productivity, to make our reliability investments go further for our customers.

But the customer's place within the electricity system is also evolving. Customers are no longer just consumers of electricity, but also generators, sellers and managers of energy, equipped with unprecedented digital tools and a growing list of energy options. The expected growth in distributed energy generation and storage, combined with the product innovation and market convergence that will occur with the emerging internet of things, will present new possibilities for customer choice, control and convenience. As a result, customers will come to play a more dominant and pivotal role in the energy marketplace.

This emerging landscape will be challenging for utilities that fail to adapt; but it also presents a market for new products and services and unprecedented opportunities to enhance customer value and service. To realize these opportunities, utilities will need to make significant changes in the way they do business. In particular, they will need to increase their focus on meeting customer needs, and creating a more effortless and engaging customer experience. They will need to expand customer value by providing a broader range of products and services, in keeping with the growing range of energy options available to customers. And they will need to consider strategic partnerships that complement and supplement their core strengths.

With this in mind, in 2015, Hydro Ottawa created the position of Chief Customer Officer (CCO), with an enterprise-wide mandate to enhance the quality of our customers' interactions with our company. Hydro Ottawa is one of very few utilities to have taken this step. The CCO will reflect the face and voice of the customer within the company, and lead our efforts to enrich the customer experience.

What is a Smart Grid?

"The smart grid harnesses the power of information technologies to monitor, control, and optimize the use of the electricity system. These efforts are designed to increase efficiency, reduce outages, integrate more renewable forms of generation, and empower customers to more effectively control their energy use."

"Smart grids... redefine the way electricity consumers are connected to the system that serves them.... By 'connecting the customer to the control room,' smart grids open up whole new possibilities – where consumers decide how much to use or sell depending on what the price is."

Independent Electricity System Operator

www.ieso.ca



We also adopted a whole of company Customer Experience Strategy, aimed at achieving five strategic imperatives: developing a customer centric culture, knowing our customers, improving customer touchpoints, providing leading services and products, and enhancing our technologies and processes. This strategy will increase customer choice, convenience, control and ease of communication with Hydro Ottawa.

Our approach will include:

- a focus on detailed customer knowledge to allow us to anticipate and respond to customer needs in a personalized way;
- effective and innovative use of technology and communication to enhance the customer experience; and
- the development of targeted services and products that help our customers achieve their energy objectives and create value for our shareholder.

This last point means that our customers can expect to see new products and services from Hydro Ottawa in the coming years. Our services should reflect the range of energy options and uses available to our customers, and make it easier for them to adopt innovative energy solutions. Our strategy will be guided by what customers want, but is likely to include a greater role in solar generation, energy storage, and electric vehicle charging. We will also look at on-bill financing options that could spread the costs of implementing innovative technologies and increase adoption rates.

In addition to expanding what we offer, adapting to the new energy landscape demands that we re-examine how we offer products and services as well. The pervasive use of mobile devices and the emergence of the internet of things mean that no customer-focused company can ignore the increasing importance of the digital marketplace. During the course of this Strategic Direction, Hydro Ottawa will continue the digital transformation of our business, using the power of mobile and digital technology to offer service to our customers anytime and anywhere, in a more engaging and effortless manner. We will improve our use of data to offer personalized service and improve customer-facing operations. And we will work to align culture, business structure, processes and technology in the service of the customer.



A prominent element of this strategy will be a focus on mobile service offerings. According to Catalyst, 68% of Canadians owned a smartphone in 2015 – a 24% increase in one year – and the number of customers connecting to our website and online services using a mobile device is growing steadily. As part of our strategy to provide service and information to our customers where and when they want it, we will ensure that all of our online content and services are mobile-optimized, and will develop mobile applications that provide the functionality customers are looking for in a convenient and engaging format.

The transition to a Smart Grid is another important component of digital transformation. This is already under way, and will be an important driver of customer value in the next 20 years. If, as suggested earlier, the electricity ecosystem is changing to one that involves two-way power flows, a more central role for customers, and a broader range of buyers, sellers and energy resources, then the backbone of that ecosystem is a smart local distribution grid. While investments in the Smart Grid must be carefully considered, when done well they can provide significant value to electricity consumers. A study by Navigant for the Ontario Ministry of Energy estimates that smart grid investments in Ontario between now and 2035 – most of which will be made by local distributors – have the potential to deliver a net benefit of $6.3 billion, mainly in economic and reliability benefits, along with some environmental benefits. Hydro Ottawa has developed a Grid Transformation Plan that sets out a prudent and measured approach to Smart Grid development, building on the advanced metering, grid intelligence and self-healing technologies we have already deployed.

Like many other forms of technological innovation, the Smart Grid is not a destination, but an ongoing process of integrating technologies and applications that provide a benefit to customers. Our Grid Transformation Plan will proceed in lockstep with our Customer Experience Strategy, and will be tightly focused on enhancing customer value.

A central characteristic of the Smart Grid is that it merges the distribution system with high-performance communications – a powerful melding of operational and information technologies. To achieve this, Hydro Ottawa has embarked on a multi-year plan to upgrade its telecommunication infrastructure, including the installation of over 281 kilometres of dark fibre

to support a high speed optical network in a self-healing redundant loop. When complete, there may be opportunities to leverage this infrastructure to help meet the broadband needs of our community, through "Smart City" initiatives and/or through strategic partnerships with businesses and the MUSH sector (municipalities, universities, schools and hospitals).

This underscores the fact that a Smart Grid is a foundational component of a Smart City, and there may be opportunities to collaborate for broader community benefit. The conversion of Ottawa's streetlights to intelligent LEDs is another example. This technology provides not only adaptive lighting (dimming) and asset management capabilities (notification of burnouts before they happen), but also community safety features. For example, it can detect gunshots and automatically shift to maximum lighting in the affected area, making it nearly as bright as day.

Conservation and Demand Management (CDM) programs also present an excellent means of enhancing customer value. Hydro Ottawa has been involved in the design and delivery of award-winning CDM programs since 2005. Since 2011, all electrical utilities in Ontario have been assigned mandatory CDM targets under the terms of their distribution licences. Those that meet and exceed their targets benefit from financial incentives.

Between 2011 and 2014, Hydro Ottawa's CDM programs helped our customers to conserve 414.9 gigawatt hours of electricity – equivalent to removing 54,000 homes from the grid. Under a new six-year plan (2015-2020), our CDM programs are expected to achieve another 395 gigawatt hours in savings. At an estimated cost of 4.4 cents per kilowatt hour of energy savings (much lower than the cost of generating and delivering a kilowatt hour) these programs represent excellent value to our customers.

Our Talent Management Strategy will also continue to play a central role in enhancing customer value, helping to embed a customer-centric culture throughout the organization. Customer focus is emphasized at all stages of the talent management lifecycle, from resource planning, hiring and deployment, to training, development and performance management.

4.4.2 FINANCIAL STRENGTH

Hydro Ottawa has continued to achieve strong financial results over the past several years, meeting and exceeding the targets set out in our previous five-year plan. Our objective over the next five years is to continue this trend of solid financial performance, while creating sustainable growth in our business and our earnings. To achieve this, Hydro Ottawa will maintain a focus on strategic growth within our core areas of strength.

Since the introduction of a dividend policy in 2004, Hydro Ottawa has delivered almost $200 million in dividends to the company's shareholder, the City of Ottawa. Under the current plan, this total will increase to nearly $300 million by 2020.

In keeping with our previous Strategic Direction, Hydro Ottawa has achieved significant strategic growth over the past several years, particularly in our renewable generation business. As we continue to pursue this strategy, access to capital will be critically important. Among several approaches to meet this requirement, the company is seeking an amendment to its dividend policy. The amended policy would provide higher than historical dividends to our shareholder, while retaining some of the increased profits from growth within the company, to ensure we continue to enjoy access to capital on favourable terms and to safeguard our credit rating.



In total, when the expansion project at Chaudière Falls is complete, Hydro Ottawa's renewable energy capacity will be more than 128 megawatts – enough to power 107,000 households with clean, renewable energy.

As with all other elements of this five-year strategy, our plan for financial strength is based on our strategic focus on the customer. Meeting customers' needs is not only good service, it is also good business. Over the next five years we expect to meet an expanding range of needs for a growing array of customers, creating long-term value for our shareholder and reducing costs, while helping to build a smart energy future.

In executing this strategy, Hydro Ottawa will become – and is already becoming – a more vertically integrated corporation, with new affiliates operating competitive businesses that help to drive business growth. We are already playing a bigger role in meeting the increasing demand for renewable power, focusing on opportunities that offer stable revenues through long-term power purchase agreements. We will continue to grow this business throughout the course of the current plan. We will also continue to leverage our core capabilities and assets to develop new revenue streams and generate economies of scale. This includes providing an expanded range of services to our customers, strengthening our position as the "trusted energy partner" for major institutions, businesses and developments, and providing services to other utilities to enhance the value they provide. It may also include expanding our utility service territory should appropriate opportunities arise.

Electricity Distribution

For more than 100 years, Hydro Ottawa and its predecessor companies have delivered a reliable supply of electricity to Ottawa homes and businesses. That core service is the bedrock of our success.

The Ontario Energy Board's December 2015 approval of Hydro Ottawa's electricity distribution rates for the years 2016 to 2020 puts these operations on a stable financial footing throughout the period of this plan. This will allow Hydro Ottawa to make important investments in our distribution system to maintain reliable service for the future, without compromising the company's financial strength.

At the same time, revenue growth under the current regulatory model is modest, and this trend will continue throughout the term of the current plan. In order to successfully manage the challenges of aging infrastructure, grid modernization and high retirement rates in the skilled trades, which require investments in new equipment and apprenticeship programs, Hydro Ottawa will need to maintain its focus on cost containment and productivity improvement. These strategies have been an essential part of Hydro Ottawa's healthy financial performance in recent years.



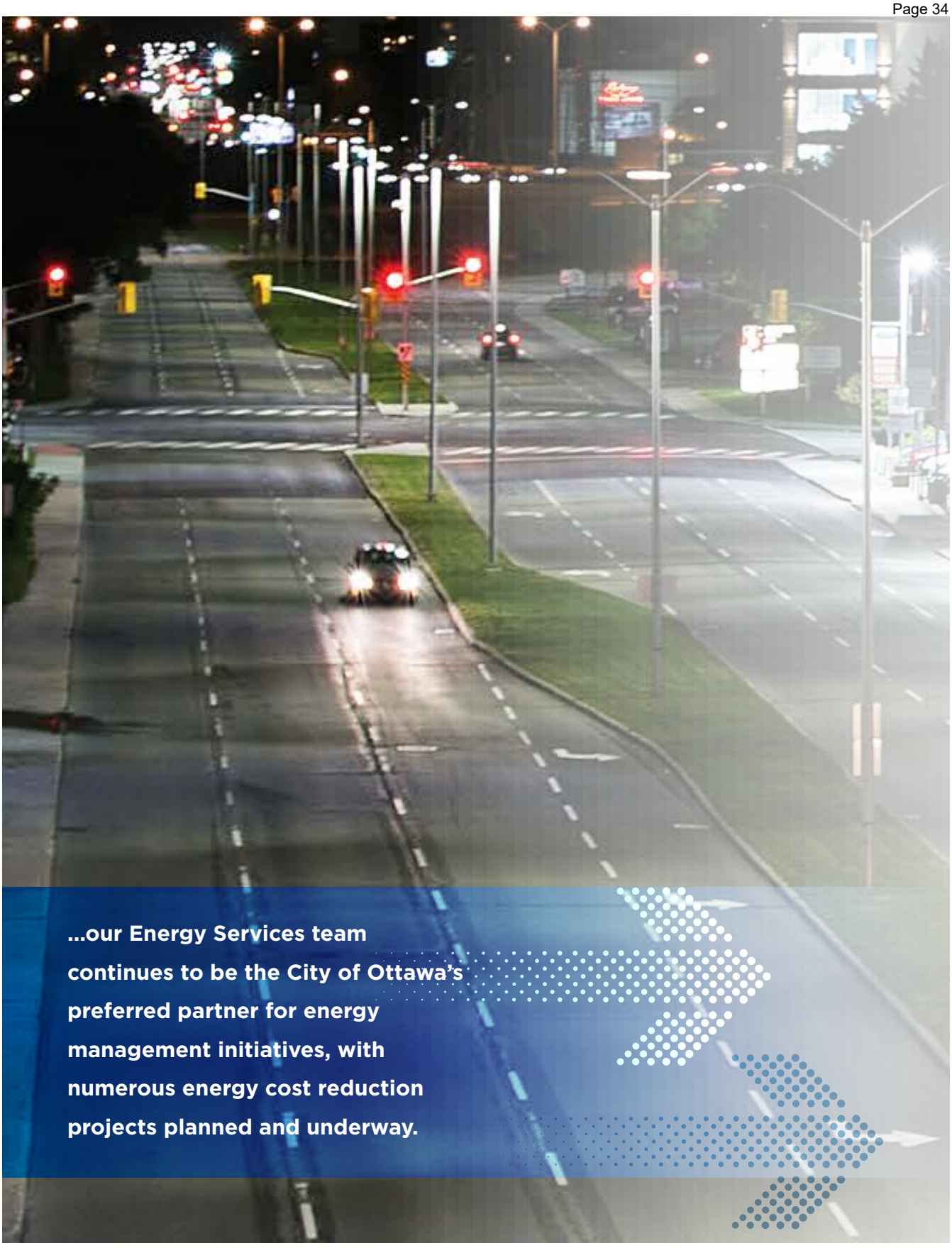
Customer growth also has an impact on financial performance, since electricity distribution involves significant economies of scale. Some customer growth occurs organically as development occurs within Hydro Ottawa's service territory. Our customer base grows by approximately 1 percent per year. More significant growth could occur through consolidation with other local electricity distribution companies. Hydro Ottawa will continue to examine opportunities to expand our service territory through mergers or acquisitions where there is a clear benefit to our customers and our shareholder. We will also continue to seek opportunities to partner with and provide services to other utilities, leveraging our core systems and our expertise to create new revenue streams and economies of scale. This element of our business strategy is described further under Energy and Utility Services, below.

Renewable Energy

Hydro Ottawa is a leader in renewable energy generation. The company is the largest municipally-owned producer of green energy in Ontario by a wide margin, and that leadership position has been significantly strengthened during the period of the previous Strategic Direction.

Run-of-the-river hydroelectric facilities account for a significant portion of this growth. Relying on the natural flow of the water source and producing no carbon emissions or pollution, this is one of the most environmentally sustainable forms of electricity generation, and represents a steady, renewable power source that is available 24/7. Moreover, the bulk of Hydro Ottawa's hydroelectric plants are located close to where power is needed most, serving Ottawa's downtown core, where demand is growing and supply is constrained.

In August 2012, Hydro Ottawa acquired three power stations and additional water rights from Domtar Corp. at Chaudière Falls on the Ottawa River, adding to Hydro Ottawa's existing hydro facilities next door. An expansion project is under way at the former Domtar site, involving the construction of a new 29 megawatt facility that will come online in 2017, backed by a 40-year power purchase agreement with the IESO. This project will also give the public access to the site, in a revitalized form, for the first time in over 100 years. This will include pedestrian and cycling access and a view of the falls from three viewing platforms.


...our Energy Services team
continues to be the City of Ottawa's
preferred partner for energy
management initiatives, with
numerous energy cost reduction
projects planned and underway.



In the coming months, Hydro Ottawa expects to complete the purchase of the Hydro Quebec facilities at Chaudière Falls – an additional 27 megawatts of installed capacity. When the transaction is complete, Hydro Ottawa will own all of the power stations at Chaudière Falls, along with the associated water rights and the ring dam previously held jointly with Domtar and Hydro Quebec. Upon completion of the expansion project at the former Domtar site, scheduled for 2017, Hydro Ottawa will have a total of 85 megawatts of renewable generation capacity at Chaudière Falls. Most of this power is covered by long-term power purchase agreements, providing stable revenues and minimizing exposure to spot market volatility.

In addition, in July 2015, Hydro Ottawa completed the purchase of 10 run-of-the-river hydroelectric facilities from Fortis Inc., in Ontario and nearby New York State. This represents an additional 30.9 megawatts of green generation capacity.

Given the company's expertise and track-record with this type of project, Hydro Ottawa continues to examine opportunities to expand its hydroelectric generation capacity, with a preference for opportunities that involve stable pricing under long-term power purchase agreements. Under the right circumstances, further strategic growth of this nature could occur within the time frame of the current plan.

In addition to its waterpower assets, Hydro Ottawa is the majority owner of two landfill gas-to-energy plants, at Trail Road and Moose Creek, with a combined generating capacity of 10.2 megawatts. This technology has matured in recent years, and is providing growing production and revenues, along with the environmental benefits of producing clean energy from previously flared-off landfill gas. In 2017, the Trail Road facility will hit 10 years of successful operation, and there is potential to expand both plants by approximately one megawatt each during the period of this plan.

In total, when the expansion project at Chaudière Falls is complete, Hydro Ottawa's renewable energy capacity will be more than 128 megawatts – enough to power 107,000 households with clean, renewable energy.

Solar power, distributed generation, co-generation, and district energy opportunities also remain a focus for future growth. Work is under way to install solar panels on the rooftops of 8 municipal buildings owned by the City of Ottawa, totalling 2.4 megawatts of capacity.

Energy and Utility Services

A third driver of financial strength over the next five years will be the services we provide to a growing range of customers to help them meet their energy needs and objectives, and to other utilities to help them enhance the value they provide. These services can be grouped into two categories. In both cases, they leverage the existing assets and expertise of Hydro Ottawa and its subsidiary companies:

Energy Services: providing innovative solutions to help consumers, businesses and communities meet their energy objectives, through energy management, energy retrofits, conservation, efficient streetlighting, energy generation, energy storage, district energy, demand response, and greenhouse gas reduction, monitoring and reporting, among others; and

Utility Services: leveraging our core systems and expertise to help other utilities to enhance the value they provide, creating new revenue streams and economies of scale.

In addition to the broad range of CDM programs that the company offers, Hydro Ottawa has long been a leader in energy management services, helping larger customers (commercial, industrial and institutional) as well as the City of Ottawa to reduce their energy costs. These services range from opportunity analysis to full design and implementation of "turnkey" energy efficiency projects. Since 2014, our capability in this area has been strengthened through our partnership with Noveda Technologies, whose EnergyFlow Monitor tracks energy and water use in real-time at one-minute intervals and provides online access anytime, anywhere. Hydro Ottawa is the exclusive Canadian distributor for EnergyFlow products.

As the range of options available to our customers expands to include energy generation, energy storage, district energy, and demand response opportunities, among others, Hydro Ottawa is expanding the range of services it provides, drawing on its core expertise with renewable technologies and infrastructure design, construction and management. These capabilities will make Hydro Ottawa a partner of choice for many customers, particularly for projects and facilities with significant scale, and our goal is to be a trusted energy advisor across the full range of options. In some cases, this may involve advisory services or project management only, while in other cases it may involve the design, construction and/or ownership of energy infrastructure. Our approach will be versatile and tailored to the customer's needs and objectives.

As part of this business line, our Energy Services team continues to be the City of Ottawa's preferred partner for energy management initiatives, with numerous energy cost reduction projects planned and underway. In connection with this partnership, between 2016 and 2020, Hydro Ottawa will complete a conversion of Ottawa's streetlights to efficient LEDs with adaptive lighting technology, and will assume responsibility for streetlight maintenance. This conversion of 58,000 streetlights will pay for itself in approximately six years, and thereafter will save the City an estimated $4 million per year in energy costs. Maintenance costs will also be lower, as LED fixtures last longer. Hydro Ottawa has completed a similar conversion in Pembroke, and is actively pursuing opportunities to provide similar services to other municipalities.

We will also proactively seek opportunities to partner with other utilities in service delivery. For example, we currently provide planning and delivery of CDM programs on behalf of Renfrew Hydro Inc. This approach could be replicated elsewhere, and extended to other types of services where we have expertise, such as asset management, design and construction, smart grid development, human resources, customer contact and billing, among others. 21st century utilities require sophisticated and expensive systems for customer service management, billing and collections, and the safe and efficient operation of increasingly "smart" distribution networks. These systems may be out of reach for smaller utilities. For Hydro Ottawa, by contrast, leveraging assets and expertise to provide these services to other utilities can create synergies that deliver savings to ratepayers, and additional value to our shareholder.

In addition, Hydro Ottawa is helping to commercialize technologies that have proven effective in its own electricity distribution business – for example, in the areas of power quality monitoring and utility cable testing.

In sum, energy and utility services are set to become a bigger part of Hydro Ottawa's business, and a bigger contributor to its financial strength. This will result in a more vertically integrated business structure, with complementary business lines and competitive affiliates helping to drive business growth.

4.4.3 ORGANIZATIONAL EFFECTIVENESS

The strategic objectives outlined in this plan represent an ambitious agenda for enhancing customer, shareholder, and community value. Achieving these objectives will require an effective and constantly learning organization, with the right skill sets and organizational capacity to deliver on existing and new business lines.

In pursuit of this goal, we will cultivate a culture of innovation and continuous improvement, focusing on three outcomes in particular: a safe and healthy work environment; an engaged, aligned and prepared workforce; and efficient and effective operations that enhance the customer experience.

As our business is changing, the profile of our workforce is changing as well. It is increasingly diverse in age, skills, background, belief, ethnicity, sexual orientation, and in many other ways. We aim to be a great employer for great people, and to create a thriving and respectful workplace for all of them.

Embracing Change and Disruption

An essential element of our strategy for the next five years is to ensure Hydro Ottawa is ready to embrace change and disruption in our sector. In a period of significant transformation, the ability not only to accommodate change, but to make the most of it, is likely to be a distinguishing characteristic of those utilities that continue to thrive. To ensure Hydro Ottawa is one of those companies, we will:

- **Cultivate awareness** – foster awareness of the forces that have the potential to disrupt our business and industry, so we can take action today to prepare for disruption's impact tomorrow;
- **Build the right culture** – develop a resilient, innovative culture so we can withstand disruption in the future while taking full advantage of today's opportunities;
- **Foster agility** – embrace new ways of working and making decisions to avoid becoming mired in the bureaucracy that can bring change to a halt; and





...we will acquire and deploy the best people, technology and financial resources so we can be more resilient and competitive in the face of disruption.

- **Develop and deploy effective resources** – acquire and deploy the best people, technology and financial resources so we can be more resilient and competitive in the face of disruption.

Health and Safety

A fundamental component of Hydro Ottawa's commitment to operating efficiently and effectively is the very high priority we place on protecting the health and safety of our employees and our community.

We have established an integrated health, safety and environment management system (HSE) that has achieved and maintained certification to the international standards of Occupational Health and Safety Assessment Series (OHSAS) 18001 and International Organization for Standardization (ISO) 14001 since November 2007. We provide safe work practices training for all employees consistent with industry best practices, and our company's safety performance has been solid, with the number of medical aid injuries, the number of lost work days, and the lost workday severity rate all declining over the past few years. Important priorities for the coming years include ensuring our HSE policies and practices are being adhered to by our contractors, expanding these programs to newly acquired companies and employees in a timely manner, and continuous improvement across the HSE system. Health and safety will continue to be a primary focus for the company.

Workforce Capacity and Capability

A highly skilled, properly trained and knowledgeable workforce is essential to Hydro Ottawa's continued success. Like many other companies and utilities, Hydro Ottawa faces challenging workforce demographics that require a concerted response. The company's comprehensive Talent Management Strategy is aimed at anticipating and meeting talent needs, through planning, talent attraction and acquisition, effective deployment of resources, and performance management and development. Hydro Ottawa aims to be a great employer for great people, and the company has been consistently recognized as a top employer across a range of categories.

More than 40 percent of Hydro Ottawa's workforce is expected to retire in the next 10 years. This represents a loss of 7,423 years of experience, including 4,784 years of trades and technical experience. Sixty-six percent of frontline supervisors and managers in trades and technical occupations are expected to retire by 2024.

To ensure success, we have increased our focus on renewing our workforce by attracting and developing young workers. It is not simply a matter of recruiting replacements for retiring workers; we must also plan for and facilitate an effective transfer of knowledge and skills from our veteran workforce to the next generation, including the next generation of people leaders. At the same time, young workers bring a fresh perspective and new skills to our workforce.



In recent years, Hydro Ottawa has been recognized as a leader both in older worker and retiree engagement, through our multiple-award winning "Prime Time" program, and as one of Canada's Top Employers for Young People (2014, 2015 and 2016). This success in engaging the full demographic spectrum of our workforce facilitates the transfer of knowledge and skills from one generation to the next. Our apprenticeship and intern programs also contribute to this objective, including our partnership with Algonquin College in the delivery of an award-winning two-year Powerline Technician Diploma Program and our Engineer Intern Training and Development Program.

We are also working to attract and develop new skill sets that will be needed as we work toward a smart energy future. This will ensure we are able to build and sustain relationships with our customers, innovate and transition to new technologies, develop new products, services and work processes, and meet changing business and regulatory demands.

Efficiency and Productivity

One of the central challenges facing Hydro Ottawa and other utilities is the need to invest heavily in the replacement and modernization of aging infrastructure without putting upward pressure on customer rates, which are already rising due to increased electricity commodity prices. In this context, achieving efficient and effective operations has never been more important to Hydro Ottawa; we must continually find ways to work smarter and more efficiently – and we are doing just that.

Since 2007, Hydro Ottawa has set and achieved annual productivity improvement targets, focusing on maximizing the efficiency and effectiveness of our operations by reducing waste and optimizing productivity at every opportunity. This will continue to be a central focus, with ongoing efforts to improve the efficiency of our capital work, reduce operating costs, maximize the productivity of our workforce through organizational rightsizing and right-skilling, and implement technology solutions that enhance customer value while improving efficiency. Through these efforts, Hydro Ottawa has been able to minimize rate increases related to our operations (distribution rates), although electricity commodity rates (which are beyond Hydro Ottawa's control) have and will continue to rise.

Leveraging Technology

Choosing and deploying the right technologies is a crucial aspect of business success for modern utilities. At Hydro Ottawa, our technology decisions are based on two basic considerations: enhancing service to our customers, and creating efficiencies that will increase our competitiveness and improving functionality to be more agile and resilient in the face of industry disruption. Over the course of this plan, Hydro Ottawa will continue to adopt innovative technologies that solve business problems and enhance customer value.

One way Hydro Ottawa is leveraging technology to enhance productivity is through our "Anything, Anytime, Anywhere" approach – making technology tools available to our workforce where and when they are needed. Putting better tools in the hands of field workers improves efficiency and increases wrench time.



...we will continue to emphasize four aspects of good corporate citizenship: good governance; stakeholder engagement; environmental sustainability; and investing in our community.

In addition, the use of enhanced Asset Investment Planning tools is improving the efficiency of capital project planning and execution, and customer self-serve technology enhances the customer experience while reducing operating costs.

Recognizing that the traditional distinction between information technology and operational technology is becoming outdated, in early 2016, Hydro Ottawa integrated both functions under our Chief Information Officer. This will enable more effective technology planning and strategy, more seamless interaction of systems and applications, and more robust cyber security practices.

A critical mandate for Hydro Ottawa's technology team is to ensure the security of our distribution system and our information systems against cyber threats such as hackers. The company works closely with industry partners and security agencies, and adopted an updated cyber security roadmap in 2015. Hydro Ottawa will continue to draw on both internal and external resources to ensure we stay abreast of new developments in this fast-moving area.

4.4.4 CORPORATE CITIZENSHIP

As a community company that delivers an essential service to Ottawa residents – and whose predecessor companies have done so for more than 100 years – contributing to the well-being of the community has always been a part of Hydro Ottawa's core mandate. We know how much energy matters to the daily lives of our customers and our community, and the responsibility to provide it efficiently and reliably has shaped the way we see ourselves as a company.

Out of this mandate, a commitment to fulfill our governance, environmental and social responsibilities as a company has naturally evolved. This is a commitment we will continue to enhance over the course of this plan.

This approach is not only true to our roots as a company; it enhances our corporate performance as well. As leading companies have come to realize, good corporate citizenship can and does drive growth in value, as stakeholder trust creates new opportunities, reassures regulators, increases customer loyalty, and attracts good business partners and talented employees.

To deliver on our commitment, we will continue to emphasize four aspects of good corporate citizenship: good governance; stakeholder engagement; environmental sustainability; and investing in our community.

Corporate Governance

Good corporate governance is the glue that holds together responsible business practices. By making governance a core focus over the past several years, Hydro Ottawa has established leading governance practices for a company of its size and mandate, and adheres to high standards of integrity, transparency and disclosure. We will continue to ensure that this is the case, by regularly assessing emerging best practices, and comparing ourselves to the best-governed private and public sector organizations.

Stakeholder Engagement

We also recognize that maintaining the trust and confidence of our stakeholders is essential to the company's performance. We are committed to taking into account the concerns and interests of all our stakeholders, including employees, customers, suppliers, our shareholder and the communities and environment in which we operate. Our commitments to these stakeholders are entrenched in the guiding principles set out in this Strategic Direction. We will continue to operate with their interests in mind, and will actively encourage their participation in shaping the future of the company. Our emphasis will be on increasing our understanding of stakeholder requirements and perceptions, and timely, accurate, and transparent disclosure mechanisms and communication.

Environmental Sustainability

Hydro Ottawa is already making an important contribution to environmental sustainability by generating renewable energy and actively promoting energy conservation. Equally important, though, is the need to continuously reduce the impact of our own operations on the environment through the use of "green" technology, resource-conserving activities and practices, and other means. This has been an increasing focus for Hydro Ottawa in recent years through our Environmental Sustainability Strategy, which will be renewed and updated during the course of the current plan.

Between now and 2019, Hydro Ottawa will be replacing our office facilities and some of our operational facilities, which have reached end of life. Our new administration building will be built to a LEED Gold standard, and our operations centres to a LEED Silver standard. As such, in addition to enhancing our operations, these facilities will significantly reduce our environmental impact.

The implementation of Smart Grid technologies also has a positive impact on Hydro Ottawa's environmental performance, since it is often possible to solve outages and complete other tasks without sending a truck.

Community Investment

Our company has a proud tradition of contributing to quality of life in our community. Our United Way workplace campaigns have raised more than two million dollars in the past 15 years. Our Brighter Tomorrows Fund – a partnership with the United Way – has contributed more than $675,000 since 2011 to help housing and homelessness agencies make energy efficiency upgrades. Our electricity safety and conservation presentations educate more than 17,000 children and youth per year. And our Community Partnership Investments, along with our employees' volunteer efforts, have contributed to many worthwhile community initiatives. These efforts will continue, and will periodically evolve to achieve maximum impact and align with our role in the community.



Creating long-term value for our shareholder

5. Financial Outlook

5.1 FINANCIAL OUTLOOK

This Financial Outlook presents high-level projections for Hydro Ottawa's revenues, expenses and major capital expenditures that support the company's business lines for the period 2016-2020, and the underlying key assumptions and risks.

Hydro Ottawa's objective with respect to financial performance is to achieve sustainable growth in our business and our earnings. This creates value for Hydro Ottawa's sole shareholder, the City of Ottawa, including dividends and growth in the company's equity. It also enhances our ability to meet the energy needs of the communities and customers we serve. To achieve this objective of sustainable growth, Hydro Ottawa will continue to pursue excellence and strategic growth in our core business lines: providing efficient and reliable electricity distribution services; generating electricity from renewable resources; and providing a growing range of energy and utility services that help customers to meet their energy needs and objectives and other utilities to enhance the value they provide. We will continue to invest heavily in our core distribution and generation assets, while improving productivity across all of our businesses and pursuing strategic business growth opportunities that leverage our strengths.

Hydro Ottawa has achieved solid financial results since our *2012-2016 Strategic Direction* was issued, and the aggressive growth targets set out in that plan will be surpassed. This continues a trend of consistent and sustained growth in net income and shareholder equity over time. Since the introduction of a dividend policy in 2004, Hydro Ottawa has delivered almost $200 million to the City of Ottawa. This five-year Financial Outlook projects continued growth in shareholder value, including $185 million in net income over the 2016-2020 period and dividends totalling $100 million, bringing the cumulative dividend total to $300 million by 2020.

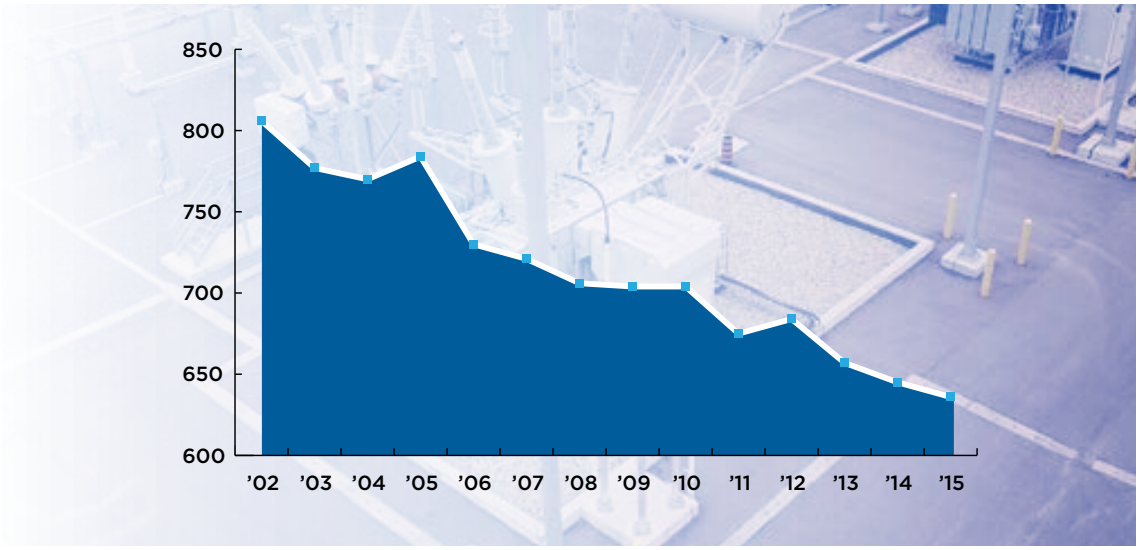
The financial projections set out here reflect a continued focus on strategic business growth in our core areas of strength, as set out in the preceding sections of this Strategic Direction. They take into account current and future economic trends, the regulatory environment, and capital investments required to maintain and upgrade our electricity distribution and generation infrastructure.

5.1.1 REVENUE PROJECTIONS

Hydro Ottawa's revenues are projected to grow on average by 6.0% over the period of the Financial Outlook. This reflects continued strategic growth in generation, and energy and utility services. Electricity distribution revenues

This five-year Financial Outlook projects continued growth in shareholder value, including $185 million in net income over the 2016-2020 period

Average Monthly Consumption – Residential



are projected to grow moderately due largely to the significant capital investment in aging infrastructure, and projected customer growth partially offset by declining average consumption as indicated in the chart above.

The largest component in Hydro Ottawa's revenue forecast is the cost of power recovered from the customer through provincially established rates. Cost of power is a flow-through amount, which poses limited risk to Hydro Ottawa's financial performance either positively or negatively.

Hydro Ottawa filed a Custom Incentive Rate-setting application with the Ontario Energy Board (OEB) in April 2015 for electricity distribution rates for the period January 1, 2016 through December 31, 2020. Hydro Ottawa's decision to file a Custom Incentive Rate application was based upon the Company's significant capital requirements during this period. The OEB held an open and transparent hearing process and, in the course of developing the 2016-2020 rate application, Hydro Ottawa invited public comment on the proposed rate application and hosted a public presentation session. The OEB rendered a decision on most elements of the application on December 22, 2015, and on February 25, 2016 for pole attachment rates. For an average Hydro Ottawa residential customer, the average change in distribution rates from 2016 to 2020 will be approximately 2.6 percent.

As directed by the OEB, Hydro Ottawa is incrementally transitioning residential customers to a fully fixed distribution charge by 2020. The distribution charge is the revenue retained by Hydro Ottawa, and represents less than 20 percent of the total bill. The remaining 80 percent includes commodity charges, provincially regulated charges and harmonized sales tax. These revenues pass through Hydro Ottawa to electricity generators, Hydro One, the Independent Electricity System Operator, the provincial government, and others.

Generation revenue has increased significantly in the last five years and this trend will continue.

The most notable increase in generation revenue is projected to begin in 2017 from the completion of the new 29 megawatt hydroelectric facility at Chaudière Falls. Generation revenue projections are based on pricing in accordance with secured Power Purchase Agreements and open market projections, along with 40-year water level data to guide production assumptions.

The Energy and Utility Services business lines assume the continuation and expansion of the existing business model and annual revenue growth, including streetlight LED conversion and maintenance through a partnership with the City of Ottawa.

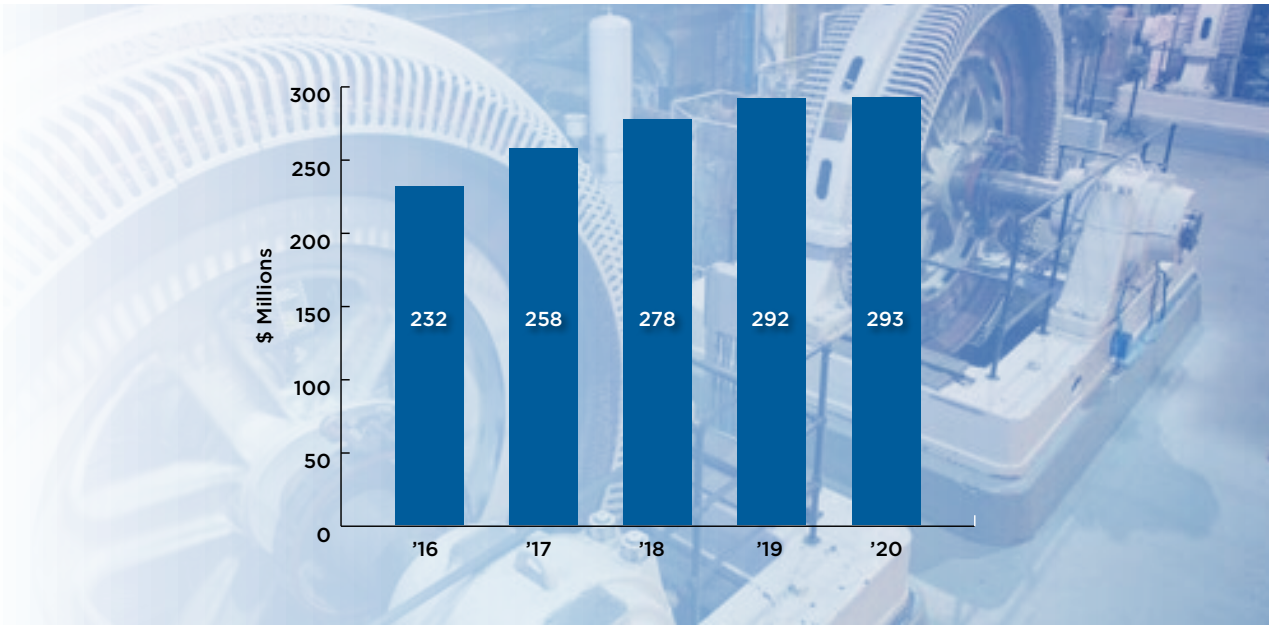
The five-year revenue profile for Hydro Ottawa, excluding cost of power flow-through, is as indicated in the chart below.

5.1.2 COST DRIVERS

FLOW THROUGH COST OF POWER

Similar to revenues, Hydro Ottawa's largest component of operating expense is the cost of power purchased from the provincial grid, which fluctuates based on the commodity price

Revenue

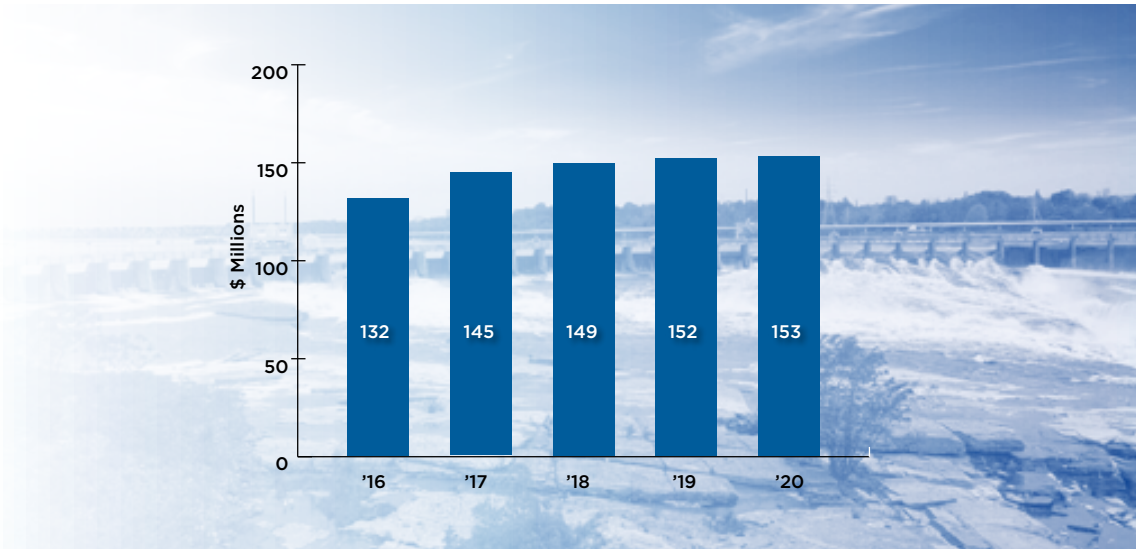


for electricity. This cost is designed by the OEB to be fully recoverable through the commodity rates charged to the customer. In the absence of regulatory change, there is limited risk to Hydro Ottawa's financial performance from the cost of power. Risk arises from Hydro Ottawa Limited's full responsibility for bad debts, and cash flow impacts from commodity rate increases, as the cost of power is the single largest monthly expenditure of the company.

OPERATING, MAINTENANCE AND ADMINISTRATION COSTS

The most significant cost directly controllable by management is operating, maintenance and administration (OM&A) expenses. This includes internal labour costs, direct material and program costs, and external service contracts. Hydro Ottawa Limited's approved 2016-2020 electricity distribution rates prescribe OM&A increases to a minimal 1.91% per annum. Productivity improvements and cost containment are a must to offset the inflationary cost of labour, materials, and external service contracts integral to our business. These include operational reviews, reduced overtime usage, cost-effective benefit plans, renegotiation of external service contracts, management of overdue customer accounts and schedule optimization of crews and dispatch, amongst others.

Operating, Maintenance and Administration Expenses



Gross Capital Expenditures



Sustainment of Distribution and Generation Infrastructure

Other includes Facilities Implementation Plan

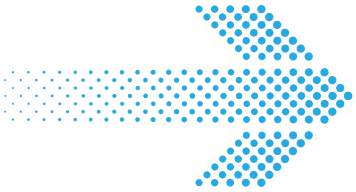
Third Party Work

Chaudière Construction

CAPITAL EXPENDITURES

Aging infrastructure remains a reality for Hydro Ottawa and other utilities, with implications for service reliability. The need to invest heavily in electricity distribution infrastructure to maintain a high-quality service represents a significant cost driver. Electricity distribution and generation reliability is contingent upon life-cycle investment programs. The regulated distribution business will incur the majority of capital expenditures, as we continue to invest to sustain the reliability of the distribution system through rehabilitation and upgrades, as well as expansion of sub-stations to accommodate customer growth and provide sufficient capacity for emergency and peak load situations.

Other projects that are critical to Hydro Ottawa's business strategy also require significant capital investment, including the construction of a new 29 megawatt generation facility at Chaudière Falls, a facility renewal plan to replace end-of-life office and operational facilities, and a telecommunications plan to improve connectivity for all stations and substations.



Hydro Ottawa's investment in capital infrastructure over the period of the 2012-2016 Strategic Direction is projected to be $775 million, and this level of investment will continue over the 2016-2020 period with a projected investment of over $800 million. Hydro Ottawa's amortization expense and financing charges are reflective of this capital investment, and as a result are projected to increase over the period.

FINANCIAL PROJECTIONS

In summary, with Hydro Ottawa's Custom Incentive Rate application approved in December 2015 for the 2016 to 2020 period, funding to maintain the reliability of Hydro Ottawa's electricity distribution operations is sustained. This, combined with strategic growth in generation, the distribution network, and energy and utility services, enables the company to project $185 million in net income over the next five years.

	FINANCIAL OUTLOOK				
Consolidated Statement of Income ($millions)	**2016**	**2017**	**2018**	**2019**	**2020**
Revenues					
Power Recovery	950	979	1,008	1,038	1,069
Distribution Sales	165	172	181	194	196
Generation Revenue	22	30	42	42	43
Other Revenue	45	56	55	56	54
	1,182	**1,237**	**1,286**	**1,330**	**1,362**
Expenses					
Purchased Power	950	979	1,008	1,038	1,069
Operating, Maintenance & Administration	132	145	149	152	153
	1,082	1,124	1,157	1,190	1,222
EBITDA	**100**	**113**	**129**	**140**	**140**
Amortization, Interest & Taxes	66	77	91	102	101
Net Income from Current Operations	**34**	**36**	**38**	**38**	**39**

5.2 RISKS AND UNCERTAINTIES

The ability to manage and mitigate risk, to maintain flexibility, and to respond effectively to changes in our business environment will be critical to Hydro Ottawa's continued success.

While we are confident in our assessment of Hydro Ottawa's business environment as a whole, future events may differ significantly from what we expect. Some of our assumptions may prove unwarranted. Subsequent events could change the complexion of current trends, and not all opportunities currently envisaged may turn out to be viable.

Our Enterprise Risk Management (ERM) system establishes the infrastructure to allow us to predict and respond to risks and opportunities impacting our Strategic Direction and business activities, and to do so in an effective, consistent and integrated manner. Our five-year Business Planning cycle, with annual updates, also enables continuous review of assumptions and the state of the market in which we operate.

Some of the key factors that could adversely impact the achievement of the projected results above include the following.

Economy

The state of the local, provincial, and national economy could have a significant impact on Hydro Ottawa's business performance, through factors such as interest rates, inflation, customer credit conditions, and weakening demand for electricity and/or value-added services.

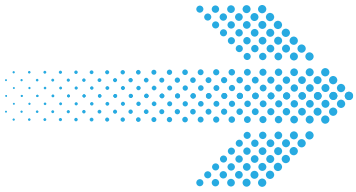
Policy and Regulatory Environment

Hydro Ottawa's largest businesses operate in a regulated environment. Our business performance could be adversely affected by significant policy and regulatory changes, including but not limited to changes in rate regulation, policies relating to the production and procurement of renewable and clean energy, conservation and demand management, the consolidation of electrical utilities, restrictions on utility service provision, or changes to license requirements.

Potential Disruption of Utilities' Business Model

The convergence of distributed energy resources (DER) with information technology (IT) could disrupt the traditional business model of electrical utilities. As IT platforms develop to tie grid data, DER data and customer-specific information together into a 'virtual power plant,' they may also become capable of 'networking' multiple





such self-contained virtual power plants into a single energy system. In time, they might be in a position to take over swaths of a local distribution company's service footprint. In addition, organizations capable of developing distribution-edge software platforms and translating them into sustainable value propositions to customers could progressively dislodge the LDC from the customer interface, reducing the opportunity for revenues from value-added services.

Diversification of Revenue: Implications for Credit Ratings

Over the last decade, the consumption of electricity in Ontario, and elsewhere in North America, has remained constant, reflecting underlying, flat economic trends, as well as the impact of conservation. In response, utility rates in general have increased in order to meet revenue requirements.

With a view to containing rate increases for its customers, and recognizing the potential disruption of the business model for electrical utilities, since 2011 Hydro Ottawa has attempted to diversify its revenue and assets by expanding its presence in unregulated lines of business, including renewable energy generation and energy management services. This will continue through the period of this strategic plan.

The need for electrical utilities to diversify their revenue and assets portfolio is slowly gaining recognition in the financial community. In the short term, however, there could be an adverse impact on Hydro Ottawa's credit ratings, which could increase the cost of borrowing.

Access to Capital

As is the case with many municipally-owned electrical utilities, the infusion of additional shareholder equity in order to achieve growth objectives may not always be a feasible option for Hydro Ottawa. As a result, there may be constraints on the Corporation's debt capacity, which could in turn affect its ability to achieve some of the growth objectives outlined in the 2016-2020 Strategic Direction.



Market Prices for Electricity

Where revenue from electricity generation is linked to market prices, there could be revenue fluctuation due to a number of factors, including: the amount of excess generating capacity relative to load in that market; the structure of that market; weather conditions which impact electrical load; growth in demand for electricity; absolute and relative prices for energy; and developments in conservation and demand management.

Exchange Rate Fluctuations

Hydro Ottawa uses the Canadian dollar as its functional currency. It already owns generation assets in the United States, and might during the next five years expand its operations and assets in that market. A significant depreciation of the value of the US dollar relative to the Canadian dollar may adversely affect the value of the Corporation's US-based assets and the related revenues. Conversely, a significant depreciation of the Canadian dollar relative to the US dollar may affect the Corporation's capacity to finance and the expected rate of return from its US investments.

Climate Change

Climate change is affecting the rate of occurrence of extreme weather events, and in some cases their severity as well. The impact of these events on North America's aging electricity grid will test utilities' capacity to respond to emergencies and restore power in a timely manner. Over the long term, grid renewal investments, such as those planned by Hydro Ottawa, should make the electricity system more robust. Regulatory and public support for such investments and the related management systems cannot be taken as a given, though expectations for utilities to be responsive, agile and resilient during and after extreme weather events are likely to remain. There could therefore be a disconnect between the climate change resilience expected of utilities and the resources available to achieve this level of resilience.

Hydrology

The amount of electricity generated at Hydro Ottawa's hydro-electric facilities depends upon available water flows and weather conditions, which vary naturally from season to season, and from year to year. Water flows may also be affected by natural disaster or through government controls and policies on water levels.



Dependence on Partners

The growth opportunities identified in the strategic plan may depend upon the presence of willing partners, and/or partners that perform to long-term expectations. An absence of willing merger or acquisition partners, or utilities and others willing to partner on utility service delivery, could negatively impact Hydro Ottawa's ability to deliver on its financial objectives, as could the underperformance of key business partners.

Workforce Demographics

Across the electricity sector, retirements are outpacing new entrants to the workforce, which could have an adverse impact on the ability of the Corporation to build a sustainable workforce and achieve its business objectives. Hydro Ottawa's investments in apprenticeships, internships, diversity, knowledge management, succession planning and retiree and older worker engagement programs are designed to manage risks relating to workforce demographics.

Technology Infrastructure

The Corporation's business performance is dependent upon complex technology systems, including customer information and billing systems, advanced metering, and operational technologies such as geographic information systems, system control and outage management systems. The failure of one or more of these key systems, or a failure of the Corporation to plan effectively for future technology needs or transition effectively to new technology systems could adversely impact the Corporation's business operations.

Cyber Security

The Corporation's reliance on information systems and expanded data transmission and exchange networks, in conjunction with the growing extent of systems and data integration within the electricity sector, increases its exposure to information security threats, including cyber security risks. A security breach, data corruption or system failure at a shared resource or common service provider, could put Hydro Ottawa's information systems and information assets at risk.



5.3 CONCLUSION

Subject to the risks and uncertainties discussed in this document, Hydro Ottawa will continue to provide efficient, reliable electricity distribution services to customers at a competitive cost, generate green power, and provide energy and utility services and conservation expertise while maintaining sustainable earnings. The company will achieve this by continuing to invest in core distribution assets, improving productivity and pursuing business growth opportunities that leverage corporate strengths.

With the 2015 approval of the 2016-2020 Custom Incentive Rate application, Hydro Ottawa has received approval for capital investment in electricity infrastructure for the next five years. Hydro Ottawa customers will continue to benefit from reliable electricity distribution with stable, moderate, and predictable rate impacts. The company also continues to actively pursue opportunities for expansion in non-regulated business lines in accordance with the endorsed strategy.

Hydro Ottawa has established a strong financial position and is well-positioned for continued growth. Over the 2016-2020 period, the company will generate significantly greater shareholder value than under the previous five-year plan.

6. Governance and Reporting

Accountability for the effective operation of the Corporation and its subsidiaries rests with an eleven-member Board of Directors, which provides direction to the Corporation on behalf of the shareholder, the City of Ottawa. The Board provides leadership for the company within a framework of effective controls that enables risks to be assessed and managed, and is responsible for supervising the management of the business and affairs of the company and its subsidiaries.

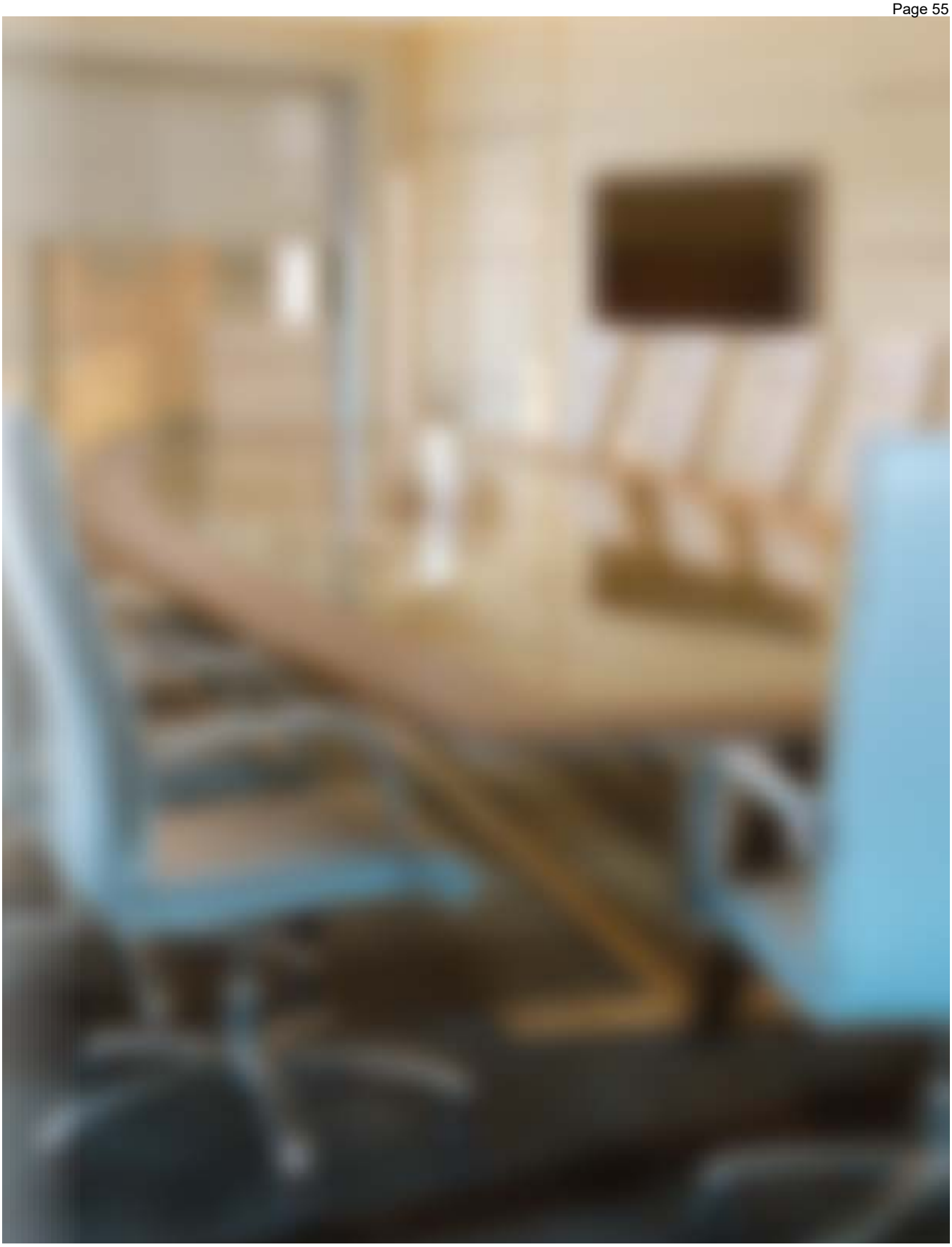
In carrying out its oversight function, the Board of Directors is guided by a Shareholder Declaration issued by Ottawa City Council and revised from time to time.

In 2006, a separate Board of Directors was established to oversee the operations of Hydro Ottawa Limited, in accordance with the Affiliate Relationships Code for Electricity Distributors and Transmitters issued by the Ontario Energy Board. The powers and functions of that board are set out in a Shareholder Declaration issued by the Hydro Ottawa Holding Inc. Board of Directors.

On a day-to-day basis, the Corporation is led by an Executive Management Team, comprising the Corporation's President and Chief Executive Officer and the senior executives of the subsidiaries and critical functional areas. This team oversees the alignment of business practices and strategies with the goals of the Corporation, and drives performance by managing risks and opportunities. The Executive Management Team is accountable to the Corporation's Board of Directors through the President and Chief Executive Officer.

The Board will monitor progress against the strategic plan on a quarterly basis and make adjustments as required by changing circumstances. The Corporation will report on progress annually to the Shareholder, at the time of the Annual General Meeting. A summary of the Corporation's financial results is provided to the shareholder on a quarterly basis through the City Manager.

Monitoring progress





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30% Post-Consumer Waste

HYDRO OTTAWA CORPORATE POLICY

Subject: Asset Management Policy		
Category: Distribution Asset Management	**Policy Number**: POL-ED-IAS0001-01	
Administrator: Director, Distribution Engineering & Asset Management	**Owner:** Chief Electricity Distribution Officer	**Approver:** President and CEO

1. PURPOSE

The purpose of this policy is to define the principles and high-level direction which Hydro Ottawa applies to asset management practices to achieve organizational and asset performance objectives. The policy describes the "intentions and direction of an organization as formally expressed by its top management" (ISO 55000 3.1.18).

2. SCOPE

This policy applies to all assets, employees, contractors, documentation, processes, and systems associated with asset management at Hydro Ottawa. The Asset Management System encompasses distribution, stations, metering and specified telecommunications assets.

3. DEFINITIONS

Corporate is defined as all Hydro Ottawa divisions.
Hydro Ottawa refers to Hydro Ottawa Holding Inc. and its subsidiaries and/or affiliates.
ISO 55001 refers to the international Asset Management System standard ISO 55001.
SAMP is defined as the Strategic Asset Management Plan.

4. POLICY DIRECTIVES

The mission of Hydro Ottawa's Asset Management System is to manage and operate its distribution and station assets to:

- enable a safe, reliable, and accessible electrical distribution system;
- create and realize long-term value for our shareholder and customers; and
- ensure alignment to our strategic objectives.

This Policy is endorsed by the Hydro Ottawa Executive Management Team. It is the responsibility of all employees to ensure its implementation and maintenance. The Director, Distribution Engineering & Asset Management, has overall accountability for this Policy and for ensuring that it is regularly reviewed and continues to remain applicable, while reflecting the changing requirements of our customers, stakeholders, and regulators.

This Asset Management Policy shall be achieved through Hydro Ottawa's Asset Management System, ensuring that we:

- Achieve performance excellence by considering the complete lifecycle of our assets;
- Develop asset management and investment plans that are sustainable, efficient, and based on an optimized consideration of costs, risks, and benefits;
- Maintain our levels of service, while supporting and creating sustainable growth in grid accessibility to accommodate additional customer load and generation;
- Support the risk management and decision-making process by utilizing asset investment planning and management tools to analyze and report information on asset performance, quality of service, and cost management;
- Focus on employee's specific skill development, sustaining the workforce, and work plans to successfully execute asset management plans;
- Comply with all legal, regulatory, and environmental requirements; and,
- Maintain effectiveness through continual review and improvement.

5. RELATED POLICIES, PROCEDURES AND REFERENCE DOCUMENTS:

IAS0002 - Asset Management System Manual
IAS0003 - Strategic Asset Management System Plan

6. EXCLUSIONS

Assets, employees, documentation, processes, and systems outside the scope of the asset management system as defined in IAS0002 are not covered under this policy.

7. ADDITIONAL POLICY ELEMENTS

There are no additional policy elements.

8. COMPLIANCE:

Policy non-compliance must be promptly reported to the Policy Owner and may result in disciplinary action.

9. APPROVAL HISTORY

Revision .00	**Release Date** August 2, 2017	**Initial Release**	**Policy Owner Sign-off:** _____ Chief Electricity Distribution Officer	**Approved by:** _____ President and CEO
Revision .01	**Revision Date** February 6, 2020	**Description of Changes** General Content Update	**Policy Owner Sign-off:** _____ Chief Electricity Distribution Officer	**Approved by:** _____ President and CEO

Scheduled Re-affirmation Date	Responsibility
February 2023	**Chief Electricity Distribution Officer**

10. POLICY EXCEPTIONS

Exceptions to the above directives and/or changes to this policy must receive written pre-authorization from the President and Chief Executive Officer. For clarification on any aspect of this policy contact the (Director, Distribution Engineering and Asset Management).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0001**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Distribution Underground Transformers

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-14	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



Asset Management Plan – Distribution Underground Transformers

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1. Introduction

Hydro Ottawa's distribution underground transformers are used to modify voltage levels to supply electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes the current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - Asset Management Policy
Hydro Ottawa - IAS0002 - Asset Management System Manual
Hydro Ottawa - IAS0003 - Strategic Asset Management System Plan
Hydro Ottawa - OIS0001 - Overhead Distribution System Inspection
Hydro Ottawa - UIS0001 - Padmount/Kiosk Transformer Inspection Procedure
Hydro Ottawa - GCS0015 - Thermographic Scanning of Power Lines and Distribution Apparatus
Hydro Ottawa - WTS0002 - Testing Used Distribution Transformers
Hydro Ottawa - GEG0001 - Asset Health Index Guideline
Hydro Ottawa - E&O intranet website - Underground Policies, Guidelines & Design Considerations
Hydro Ottawa - E&O intranet website - General Policies, Guidelines & Design Considerations
Hydro Ottawa - E&O intranet website - Underground Calculations & Tables
Hydro Ottawa - E&O intranet website - Underground Materials
Hydro Ottawa - E&O intranet website - General Materials
Hydro Ottawa - E&O intranet website - Underground Qualifications
Hydro Ottawa - E&O intranet website - Underground Construction and Bill of Materials
Hydro Ottawa - E&O intranet website - Underground Inspection & Maintenance
Hydro Ottawa - E&O intranet website - Underground Archives
Hydro Ottawa - E&O intranet website - Department Processes
Hydro Ottawa - E&O intranet website - Standard Work Methods
Hydro Ottawa - POL-Fi-013 - Capitalization Policy
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - Distribution System Code
British Standards Institution - ISO55001
Government of Canada - SOR/2008-273 - PCB Regulations
City of Ottawa - By-law No. 2008-01 - Graffiti Management

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's distribution underground transformer assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of underground transformers can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified otherwise, referring to underground transformers includes the components below which allow for the successful use of the asset.

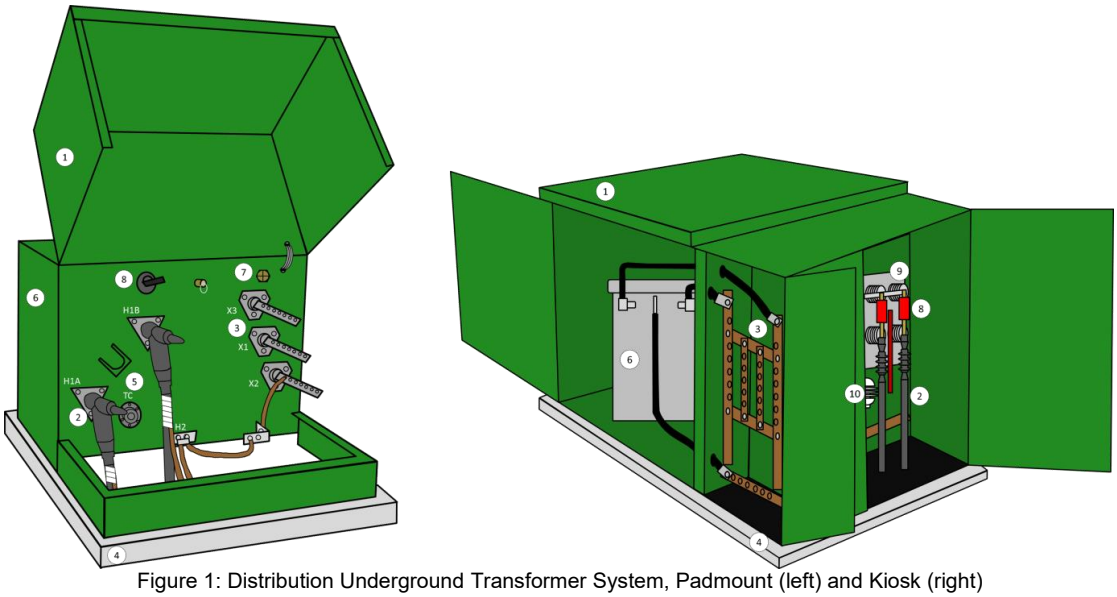


Figure 1: Distribution Underground Transformer System, Padmount (left) and Kiosk (right) (Illustrative Purposes Only)

Table 1: Distribution Underground Transformer Functions

Figure Number	Component	Function
1	Enclosure(s)	Underground transformer enclosure(s) maintain a degree of protection for the medium voltage equipment from the environment while ensuring security from the public for increased safety. Additionally, the enclosure contains the insulating oil and isolates connections from weather, animals and contaminants such as road salt.
2	Primary Connections	Underground primary connections distribute electricity at medium voltages across the service territory. It also allows for a means of installing fault indicating equipment allowing for expedited fault finding and restoration.
3	Secondary Connections	Secondary connections allow for underground transformers to supply multiple customers from a single transformer. This provides increased asset value due to effective asset utilization.
4	Concrete Base	Concrete bases provide support for underground transformers by dispersing the weight over a large area. The base also provides space for cables to be routed to the primary and secondary connections.
5	Tap Changer	The tap changer is used to regulate the voltage of the underground transformer by changing the transformer's winding ratio. The tap changer can rotate up or down to either increase or decrease the ratio with the transformer isolated. This allows the voltage supplied by the transformer to be locally adjusted within the required range

Figure Number	Component	Function
6	Core & Windings	An underground transformer's core, primary and secondary windings and oil insulation are sealed within the transformer's enclosure. These elements work together to transform electrical power, stepping down from a distribution voltage to customer supply voltage using an electromagnetic circuit.
7	Oil Level Gauge	The oil level sight gauge allows visual confirmation of the level of oil insulation within the transformer tank.
8	Fuses	Fuses disconnect the transformer in response to failed equipment or transformer overloading. The operation of the fuses isolates the failed equipment and minimizes the reliability impact to Hydro Ottawa customers, and protecting equipment from further damage. Underground transformers may contain more than one type of protective fuse.
9	Insulators	Insulators support electrical conductors and connections, without conducting electricity.
10	Surge Arrestors	Surge arresters protect the system and equipment by supressing voltage surges from various causes (e.g. lightning).

Table 2: Class, Sub-class and Components of Underground Transformers

Class	*Sub-Class*	Components Belonging to or Supporting the Sub-Class
Underground Transformer	Padmount (live front)	Enclosure, Core, Windings, Bushing, Insulating Oil, Tap Changer, Pressure Relief Valve, Oil Gauge, Insulators, Arrestor, Fuses, Barrier Board, Civil
	Padmount (dead front)	Enclosure, Core, Windings, Bushing, Insulating Oil, Tap Changer, Pressure Relief Valve, Oil Gauge, Insulators, Arrestor, Fuses, Barrier Board, Civil
	Kiosk	Enclosure, Separate Overhead Transformer with Core, Windings, Bushing, Insulating Oil, Tap Changer and Pressure Relief Valve, Insulators, Arrestor, Fuses, Barrier Board, Civil
	Submersible	Enclosure, Separate Overhead Transformer with Core, Windings, Bushing, Insulating Oil, Tap Changer and Pressure Relief Valve, Insulators, Arrestor, Fuses, Barrier Board

Hydro Ottawa owns 16,888[2] distribution underground transformers throughout the service territory. While the majority of underground transformers are pad-mounted units, Hydro Ottawa also owns kiosk and submersible transformers as shown in Figure 2.

Currently, Hydro Ottawa has known or estimated installation dates[3] stored in the Geographic Information System (GIS) for 98%[2] of its distribution underground transformers. The overall known age demographics of underground transformers in the distribution system are shown in Figure 3 below. The expected operating life of underground transformers, where the probability of failure is approximately 2% or greater, is an effective age of 53 years.

[2] Information as of December 2018
[3] Estimated installation dates are based on purchase or manufacture date of the unit.

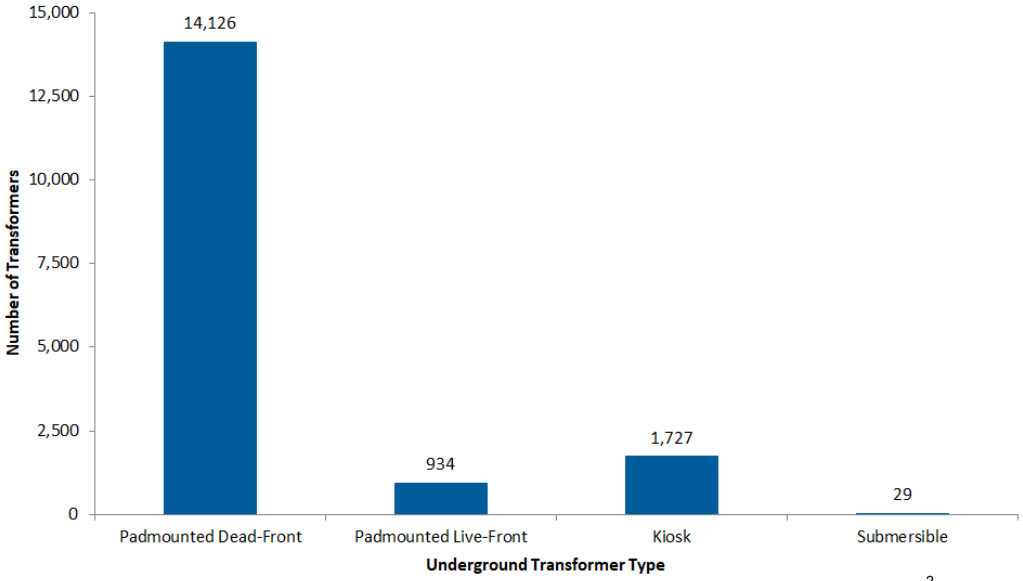


Figure 2: Count of Hydro Ottawa's Distribution Underground Transformer by Sub-Class[2]

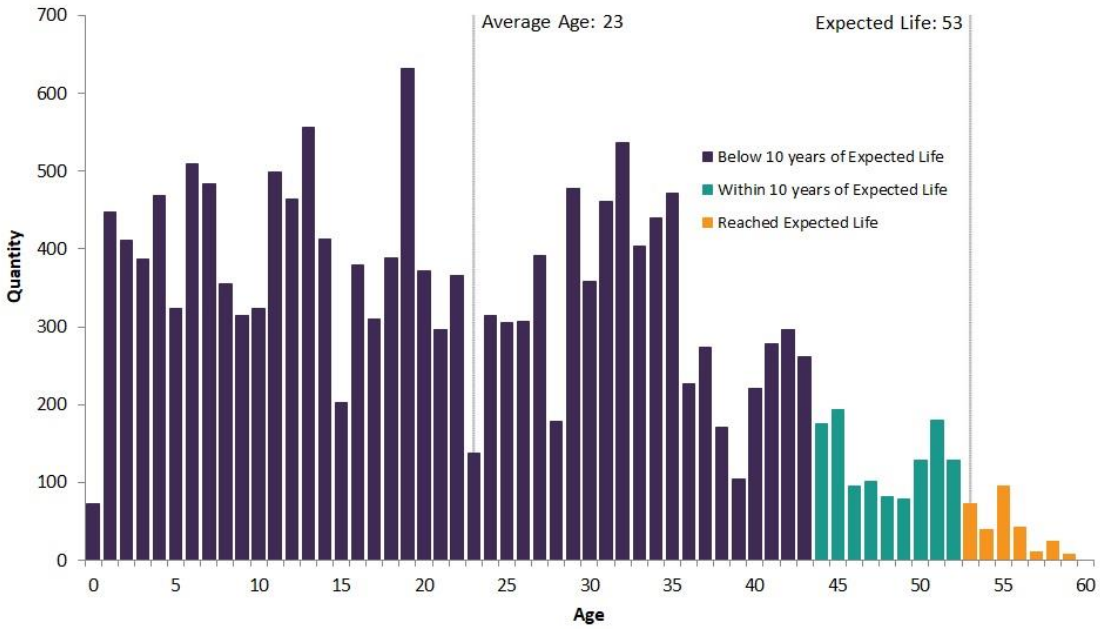


Figure 3: Hydro Ottawa's Distribution Underground Transformer Age Demographics[2]

4. Asset Management Objectives

Distribution underground transformers require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Achieve the transformation of electrical voltage to a level usable by customers
- Impact on system reliability through electrical interruptions which may be localized, affecting customers connected to that specific underground transformer, or a wider outage, affecting a large number of customers supplied by the connecting conductors
- Achieve less frequent electrical outages from external elements through the use of enclosures and added barriers
- Achieve good power quality through appropriate setting of tap changers
- Impact system reliability through enclosure failures which can limit the ability to quickly access underground transformers when required.

Health, Safety & Environment Stewardship

- Achieve employee and public safety through the containment of electrical equipment within the enclosures and through the use of locks
- Impact employee and public safety due to enclosure failure (corrosion or other damage) which can eliminate barriers to energized equipment.
- Impact environmental stewardship by releasing oil through asset failure

Asset Value

- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[4]

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually has multiple underground transformers in the same area[4]

Compliance

- Achieve compliance with the City of Ottawa's By-law No. 2008-01 – *Graffiti Management* through graffiti abatement work
- Impact compliance with the Government of Canada - SOR/2008-273 - *PCB Regulations*

In order to monitor and strive to improve the performance of distribution underground transformers, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Underground Transformers KPIs

KPI	*Target*
Underground transformer - SAIFI / 100 customers	0.60[5]
% of underground transformers with health index information	100%
% of underground transformers with very poor health index score	0%
% of underground transformers containing non-compliant PCB oil	0%

[4] Assumed based on resource and equipment requirements
[5] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections on its underground transformers. The information from the detailed inspections is used to calculate underground transformer's health index through the Asset Condition Assessment (ACA) described in section 6.2. This includes assessing equipment and connection issues through infrared (IR) scanning. The detailed inspections are completed on a 3 year cycle where areas with older underground transformers or known issues are prioritized. Hydro Ottawa has detailed inspection information on 96%[6] of its distribution underground transformers which results in health indexes shown in Figure 4 below using the ACA methodology.

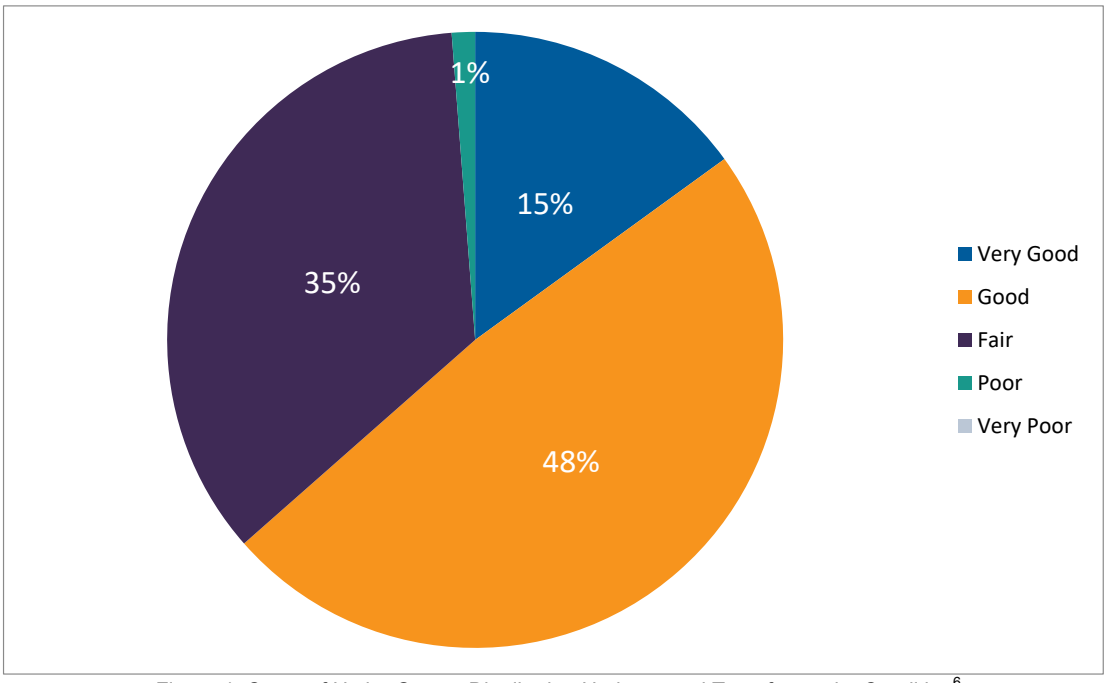


Figure 4: Count of Hydro Ottawa Distribution Underground Transformer by Condition[6]

Table 4: Distribution Underground Transformer Condition KPIs

KPI	Target	2018
% of underground transformers with a health index score	**100%**	96%
% of underground transformers with ACA compliant inspections with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of distribution underground transformers with detailed inspections producing health index scores through ACAs shown in Table 4. Hydro Ottawa plans to continue with existing inspection practices to determine a health index for all distribution underground transformers by 2021.

[6] Information as of August 2019

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Table 5: Distribution Underground Transformer Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Underground transformer - SAIFI / 100 customers	**0.60**	0.55	1.03	0.22	0.53	0.69

Hydro Ottawa currently does not meets the reliability target for outages due to defective distribution underground transformers and will continue to monitor reliability metrics for trends and improvements.

5.3. Compliance

Hydro Ottawa prioritized the inspection and oil sampling of distribution underground transformers shortly after the Government of Canada enacted regulations on the manufacturing and use of oil containing PCBs. The inspection and oil sampling allowed Hydro Ottawa to determine which assets required replacing to meet the legislative requirements.

Table 6: Distribution Underground Transformer Compliance KPI

KPI	Target	2018
% of underground transformers containing non-compliant PCB oil	**0%**	0%

Hydro Ottawa has met the compliance target for removing all distribution underground transformers which contained oil with PCB levels above that specified in the Government of Canada's - SOR/2008-273 - PCB Regulations.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades underground transformers due to various drivers described in Table 7 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Underground transformers are installed as per approved procedures and standards available in the Underground and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 7: Drivers for Distribution Underground Transformer Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to alleviate capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer, third party requests, and compliance with regulator's requirements including the Electrical Safety Authority. These include:

Customer Connections

- Upgrade an existing underground transformer to support service equipment
- New underground transformer installed to support service equipment



Figure 5: Submersible Transformer

Relocated Assets

- Relocate underground transformer to accommodate work (e.g. new developments, road widening) and eliminate clearance concerns

Table 8 shows the historical underground transformers issued to the field for various activities under System Access.

Table 8: System Access – Distribution Underground Transformer Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	216	297	186	220	155
Assets Relocated	3	8	4	17	1

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the distribution underground transformer. As described in Section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through an underground transformer failure. Hydro Ottawa replaces underground transformers each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff through visual inspections, asset failures and the health index results from detailed inspections. Table 9 shows the historical underground transformers issued to the field for various activities under System Renewal.

Table 9: System Renewal – Distribution Underground Transformer Replaced / Upgraded

Description	2014	2015	2016	2017	2018
Corrective Renewal	169	168	221	292	159
Planned Renewal	38	30	43	22	35
Assets Damaged by Third Parties	6	7	7	8	6

Corrective Renewal
Underground transformers which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual, through periodic inspections such as the Thermographic Scanning Program, or through calculating the health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 10. Where applicable, the underground transformer may be upgraded to align with future plans such as increasing capacity for future customers. The number of underground transformers replaced under corrective renewal increased in 2016 and 2017 compared to historical years due to a higher number of transformers needing attention based on new inspection data.



Figure 6: Padmount Transformer Leaking Oil

Table 10: Distribution Underground Transformer Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	Critical Replacement (Imminent Risk)
Damaged beyond repair	Minor oil leak cannot be repaired
Inoperable	Irreplaceable component
Exposure of live components to public	Insufficient health index (very poor / < 30%)
Significant loss of oil	
Health index of 0%	

Planned Renewal
Underground transformers which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews distribution underground transformer's calculated health index and underground transformers in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's underground transformer renewal program. Additionally, underground transformers may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained.



Figure 7: Kiosk Transformer

Assets Damaged by Third Parties
Underground transformers which are damaged due to third parties are replaced or repaired immediately after the area is made safe. Historically this damage has been due to motor vehicle accidents or construction equipment.


Figure 8: Padmount Transformer Damaged by Vehicle

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by underground transformer work, but may require underground transformers to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects include:

Voltage Conversion
- Reduce Hydro Ottawa's electrical system's energy losses, improve the energy capacity by increasing the supplying voltage, and/or reduce system lifecycle costs by decommissioning lower voltage equipment.

Reliability Improvements
- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades
- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Underground transformers are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they require being replaced, upgraded or installed. Additionally, the condition of the underground transformers is reviewed to determine if replacement due to end-of-life is anticipated. Underground transformers may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 11 shows the historical underground transformers issued to the field for various activities under System Service.

Table 11: System Service – Distribution Underground Transformer Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Voltage Conversion	0	7	2	0	0
System Reliability	0	0	1	0	0
System Capacity	0	0	2	0	1

6.2. Operations & Maintenance Plan

Underground Transformer Inspection and Testing
Hydro Ottawa proactively performs both a visual inspection to report deficiencies and a detailed inspection to capture ACA information on distribution underground transformers. Hydro Ottawa's employees perform visual inspections on underground transformers regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are communicated as described in the working procedure UIS0001 *Padmount / Kiosk transformer Inspection* so the issue can be rectified. Hydro Ottawa also uses external contractors to perform thermographic scanning following GNG0001 *Guidelines for Thermography* and GCS0015 *Thermographic Scanning of Power Lines and Distribution Apparatus*. Issues found from this inspection are reported to Hydro Ottawa and actioned for remedy.

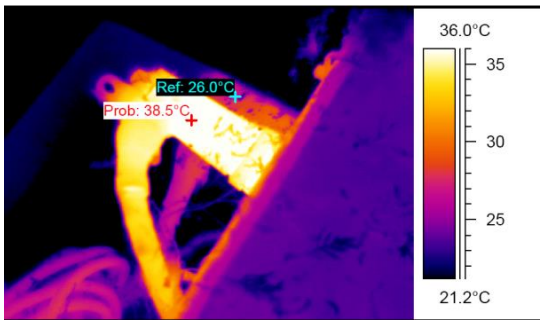


Figure 9: Underground Transformer Thermographic Scanning

In the course of the thermographic scanning Inspection, a detailed inspection is completed following the working procedure UIS0001 *Padmount/Kiosk Transformer Inspection Procedure*. This information, along with the results from the thermographic scanning, is used to calculate the overall condition of underground transformers by calculating a health index using the ACA formulation described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the underground transformer's condition. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Underground Transformer Repair
Hydro Ottawa performs reactive maintenance and repair to underground transformers when there are minor issues which don't classify the underground transformer as reaching its end-of-life (through the inspection process mentioned above). Typical repairs include replacing failed components which make up the underground transformer such as lightening arrestor or cable terminations.

Graffiti Abatement
Hydro Ottawa utilizes contractors to inspect and remedy underground transformers which contain graffiti or have rusted enclosure. This program was developed in response to the City of Ottawa Graffiti By-Law No. 2008-01 – Graffiti Management to ensure Hydro Ottawa keeps its property free of graffiti. It also allows Hydro Ottawa to work cooperatively with the City of Ottawa By-Law department to address criminal acts of graffiti to deter future acts of vandalism.



Figure 10: Underground Transformer Graffiti Removal

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses distribution underground transformers depending on their condition when they are removed from service due to various drivers. Hydro Ottawa only re-uses underground transformers following the testing and inspection per the previously mentioned inspection methods and WTS0002 *Testing Used Distribution Transformers*. The testing also determines where Hydro Ottawa may send the underground transformer to the supplier for refurbishment where Hydro Ottawa recovers value. Where an underground transformer is permanently removed from service, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. The oil used for insulation is disposed of as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of distribution underground transformers which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 10. This stock allows Hydro Ottawa to replace such underground transformers in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of over 86 underground transformers of various configurations, voltages, and sizes to be used during emergencies. Additionally, Hydro Ottawa stocks numerous quantities of various types of underground transformer components. The minimum quantity of underground transformers is based on the asset's usage and the need to have replacement assets should an emergency occur.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of underground transformers should an issue arise or more assets be required. Additionally, this includes using contractors to assist Hydro Ottawa in asset installation during emergencies.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and it is therefore difficult to accurately forecast future demand. The drivers for System Access are described in Section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual underground transformers to be installed, replaced or upgraded are shown in Table 12.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms e.g. Public Service Works on Highways Act.



Figure 11: Underground Transformer Installation

Table 12: Forecasted System Access - Distribution Underground Transformers Installed/Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	215	215	215	215	215	215	215
Assets Relocated	7	7	7	7	7	7	7

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by failed assets and information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue with existing inspections and therefore forecasts the future demand of underground transformers replaced due to corrective renewal to be in line with historical averages. Corrective Renewal replacements in 2016 and 2017 where higher than normal due to a backlog of transformers needing attention based on inspection data, as a result they have been excluded from the historical average. Underground transformers replaced due to assets damaged by third parties are forecasted based on historical averages.



Figure 12: Failed Underground Transformer

Hydro Ottawa plans to proactively replace underground transformers which result in a poor condition (health index score of at least 30% but less than 50%) through detailed inspections. These efforts may also include replacements of vault transformers with pad-mounted transformers as existing real-estate used for vault transformers are not sufficient for its replacement. This replacement strategy will prioritize underground transformers based on their ACA results, as well as, manage the long term replacement requirements for this asset class The expected annual underground transformers to be replaced or upgraded are shown in Table 13 and the expected average age of underground transformers through the planned replacement is shown in Figure 12.

Table 13: Forecasted System Renewal – Distribution Underground Transformers Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal**	130	200	200	200	200	200	200
Planned Renewal	0	12	0	9	0	0	0
Assets Damaged by Third Parties**	7	7	7	7	7	7	7

*Estimated Quantities
**Based on 5 year historical data ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require distribution underground transformers to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for underground transformers is shown in Table 14.

Table 14: Forecasted System Service – Distribution Underground Transformers Replaced / Upgraded / Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	0	0	0	0	2	0	0
System Reliability	0	0	0	0	0	0	0
System Capacity	0	0	0	0	0	0	0

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact distribution underground transformers and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to underground transformers. While more resilient than overhead construction, freezing rain, ice storms and high wind can impact underground transformer's and lengthen the time to access the equipment to perform switching and repairs. Increased flooding and ingress of water into energized equipment can negatively affect public and employee safety, damage equipment and cause outages. These events can lead to damaged assets and a reduction in Hydro Ottawa's levels of service

Additionally, during the summer months where system electricity demand is the highest, increased ambient temperature and corresponding electrical demand from equipment, such as air conditioning, can put strain underground transformers. An increase in the occurrence of high heat conditions, coupled with continued electrical demand growth can increase equipment overloading and accelerated failure due to overheating. Continued system monitoring and forecasting are required to ensure underground transformers continue to operate safely and provide value through delivering the asset management objectives.

Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to underground transformer, and there are no current climate specific adaptations for this asset. This assessment will be periodically reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program level (e.g. underground transformer renewal). These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. underground) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Distribution underground transformer assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 35 years. The difference between the expected operating life and the financial useful life is that certain drivers require underground transformers to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

Hydro Ottawa does not track the net book value of distribution overhead versus underground transformers separately. The existing net book value of Hydro Ottawa's distribution overhead and underground transformers is approximately $48.9M[7] which represents 7.2% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy*, e.g. straight line depreciation. Therefore the assets depreciate annually over their expected financial useful life. The accumulated depreciation of Hydro Ottawa's distribution overhead and underground transformers is approximately $7.3M[7].

[7] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in Section 4 used to measure performance of distribution underground transformers in achieving the asset management objectives. The performance of these assets is described in Section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with underground transformers.

Hydro Ottawa also addresses issues with distribution underground transformers through the underground standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to underground assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the IAP0021 - *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution underground transformers achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0002**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Distribution Underground Primary Switchgear

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-05	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Number Document	2020-02-18	ad/lh



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1. Introduction

Hydro Ottawa's distribution underground primary switchgear (underground switchgear) are used to support electricity delivery for customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. Assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives.. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP communicates the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management System Plan*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - UIS0002 - *Padmount Switchgear Inspection Procedure*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - GCS0015 - *Thermographic Scanning of Power Lines and Distribution Apparatus*
Hydro Ottawa - GCS0033 - *Dry Ice Blasting and Thermographic Inspection for Padmount Distribution Switchgear*
Hydro Ottawa - VIS0001 - *Electrical Equipment Vault Inspection and Maintenance*
Hydro Ottawa - WSS0015 - *Testing S&C Vista Switchgear*
Hydro Ottawa - E&O intranet website - *Underground Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Underground Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Underground Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Underground Qualifications*
Hydro Ottawa - E&O intranet website - *Underground Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Underground Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Underground Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - TBC - *Estimated Age Analysis*[2]
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-0232 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001
City of Ottawa - By-law No. 2008-01 - *Graffiti Management*
ANSI/NETA - MTS-2015 - *Maintenance Testing Specifications*

[1] Most recent revisions of the referenced documents are to be used
[2] Document in progress

3. Asset Overview

This AMP covers Hydro Ottawa's underground switchgear. While the activities described cover the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. An illustrative example of an underground switchgear can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components for switchgear within Hydro Ottawa's distribution system. Unless specified, referring to underground switchgear includes the components below which allow for the successful use of the asset.

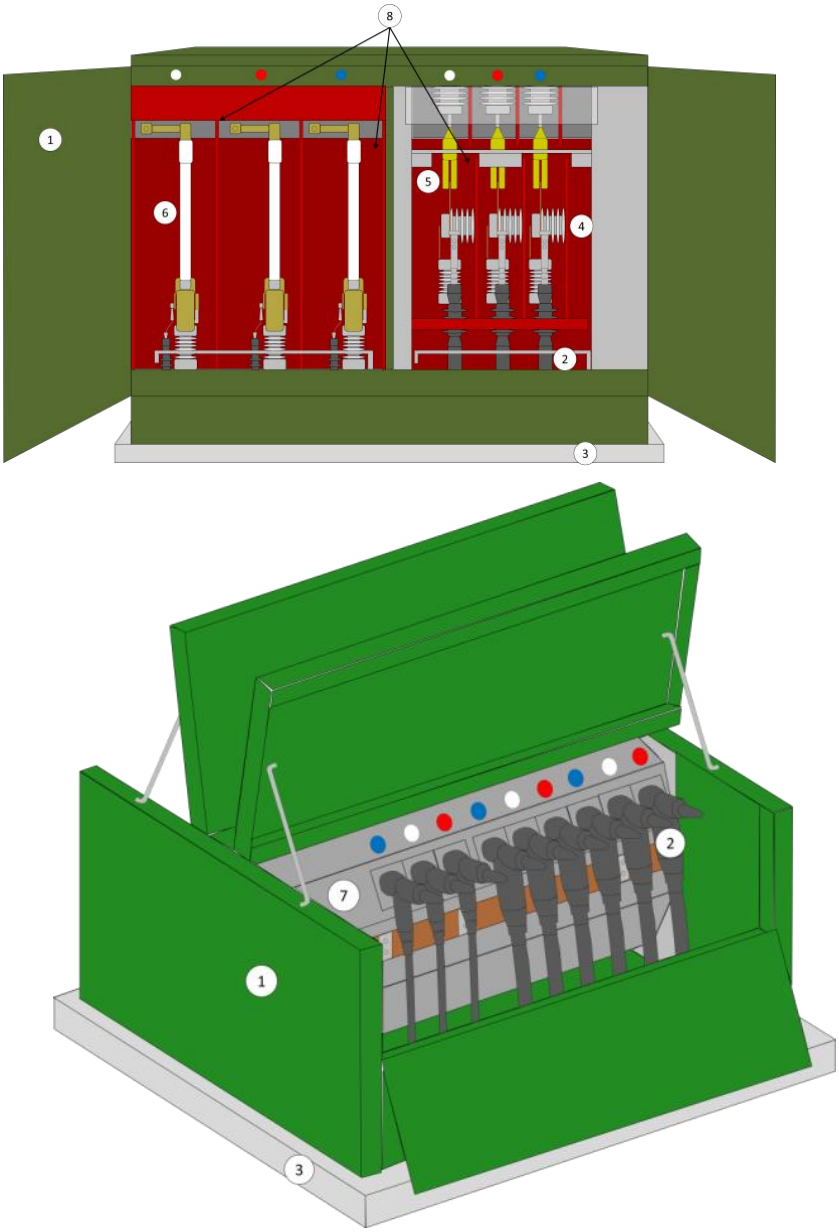


Figure 1: Distribution Underground Primary Switchgear System, PMH (top) and Vista (bottom) (Illustrative Purposes Only)

Table 1: Distribution Underground Primary Switchgear Functions as illustrated in Figure 1.

Figure Number	Component	Function
1	Enclosure	Underground switchgear enclosures maintain isolation of the medium voltage equipment from outside sources while ensuring security from the public for increased safety. Additionally, the enclosure protects the inside equipment from by isolating it from weather, animals and contaminants, such as road salt.
2	Primary Conductor	Underground primary conductor distributes electricity at medium voltages across the service territory, connecting the supply system to the switchgear. Within an underground switchgear it provides for a contact point for installing fault indicating equipment allowing for expedited fault finding and restoration.
3	Concrete Base (Pad)	Concrete bases (pads) provide support for underground switchgear by dispersing the weight over a large area. The pad also provides a work area under the switchgear to perform cable work. The pad may also be coupled with a cable chamber (manhole) to allow for increased access to underground cables (described in the Civil Structure AMP).
4	Insulator	Insulators support electrical connections while protecting equipment from the flow of current.
5	Switch Blades	Switch blades allow for the continued flow of current while providing the ability to isolate or restore power to customers through switching. The switch blades also allow for isolating the system to enable work (Hydro Ottawa or third party requested).
6	Switch Fuses	Switch fuses disconnect the circuit in response to high current levels (fault conditions or overloading). Electrical faults result in increased current which can potentially be unsafe for the public, employees and connected equipment. The operation of the fuses isolates the failed equipment and minimizes the safety and reliability impact to Hydro Ottawa customers.
7	Vista Switchgear	The Vista switchgear is fully enclosed in a hermetically sealed enclosure, containing all of the operational functionality found within other underground switchgear (see 5 and 6 above) while providing a sealed environment for the internal equipment.
8	Barrier Boards (panels)	Barrier boards (panels) are used to separate the operable equipment within an underground switchgear. While providing additional dielectric insulation, the boards isolate the impact of failure on the adjacent mechanical devices. Additionally, the boards assist in guiding the operation of the specific phase devices.

Table 2: Class, Sub-class and Components of Underground Primary Switchgear

Class	*Sub-Class*	Components Belonging to or Supporting the Sub-Class
Underground Primary Switchgear	Air	Enclosure, Civil, Switches, Insulators, Fuses, Barrier Board
	Gas (SF6)	Enclosure, Civil
	Oil	Enclosure, Civil, Switches, Insulators, Fuses, Barrier Board
	Pedestal	Enclosure, Civil, Inserts

Hydro Ottawa owns 527[3] distribution underground primary switchgear throughout the service territory. While the majority of underground switchgear are gas (SF6) or air insulated, Hydro Ottawa also owns switchgear that use oil as a dielectric medium and primary pedestals as shown in Figure 2. All Hydro Ottawa owned outdoor underground distribution switchgear are subject to a planned program of inspection, based on a 3-year cycle, using both a visual and thermographic inspection that identifies candidate assets that would benefit from a maintenance activity. Further, the air-insulated varieties of these switchgear are further subjected to a pre-scheduled maintenance regimen that includes removing dust and contaminants from the asset's operating mechanism.

Hydro Ottawa also owns vault switchgear, but does not have a proactive inspection and maintenance program for said switchgear. Details pertaining to vault switchgear Inspection and Maintenance are

[3] Information as of January 2019

shown in 6.2. Currently, Hydro Ottawa has installation dates stored in the Geographic Information System (GIS) for approximately 57%[3] of its distribution underground primary switchgear. The overall known age demographics of underground primary switchgear in the distribution system are shown in Figure 3below. The majority of underground switchgear which Hydro Ottawa does not have installation data for are expected to have been installed over a decade ago. To obtain this data, Hydro Ottawa is in the process of developing an *Estimated Age Analysis* that will be used to approximate the age of underground switchgear with unknown installation dates. The expected operating life of underground switchgear, where the probability of failure is approximately 2% or greater, is an effective age of 25 years.

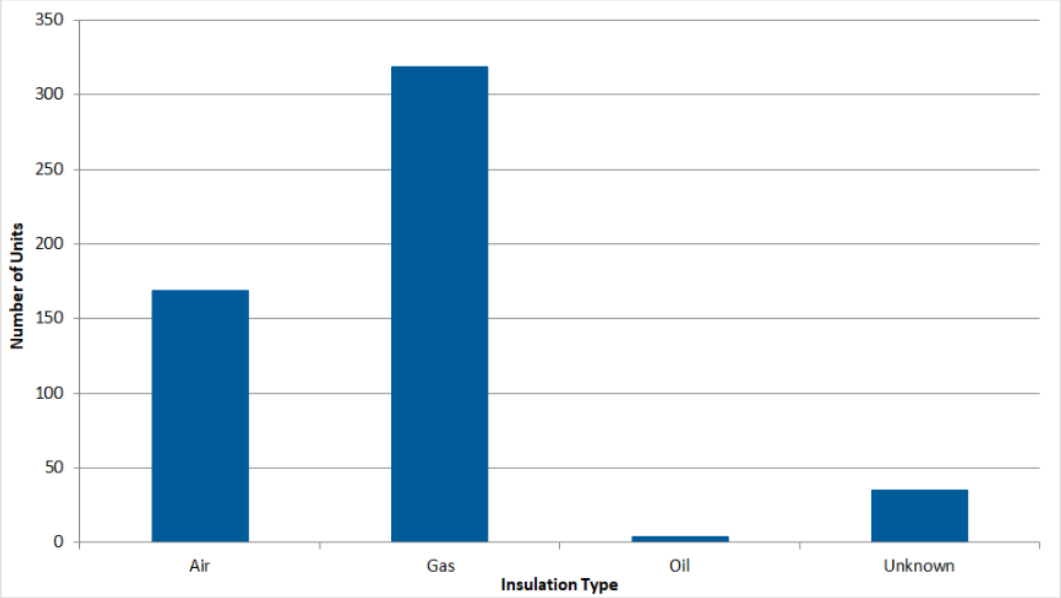


Figure 2: Count of Hydro Ottawa's Distribution Underground Primary Switchgear by Sub-Class[3]

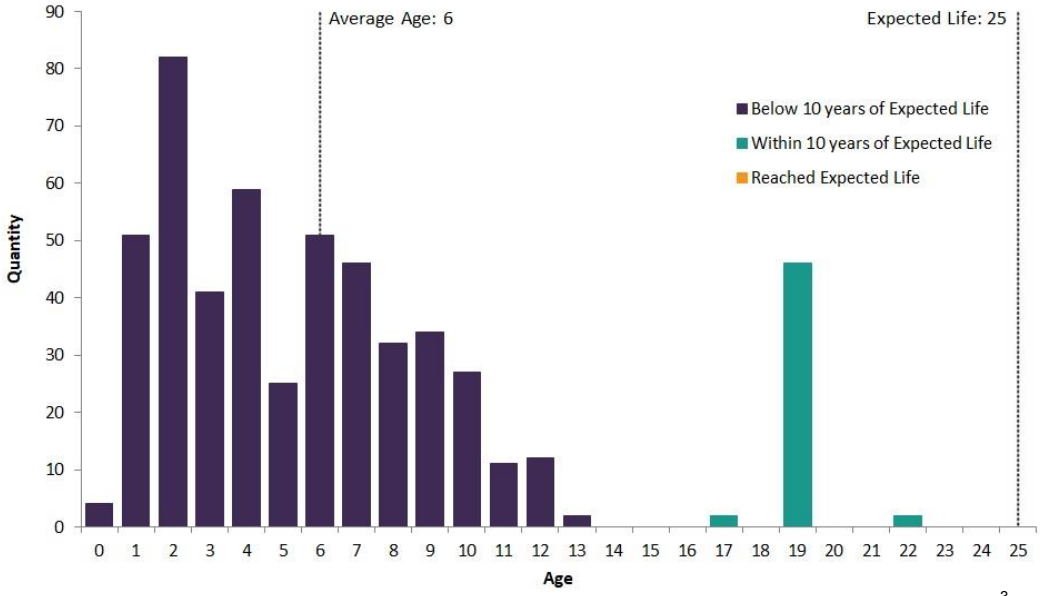


Figure 3: Hydro Ottawa's Distribution Underground Primary Switchgear Age Demographics[3]

4. Asset Management Objectives

Distribution underground primary switchgear require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact system reliability through electrical interruptions which may be localized, affecting customers connected to that specific underground switchgear, or a wider outage, affecting a large number of customers supplied by the connecting conductors
- Achieve less frequent electrical outages from external elements through the use of enclosures
- Achieve shortened duration outages through the use of remote operable underground switchgear connected to Hydro Ottawa's supervisory control and data acquisition system.

Health, Safety & Environmental Stewardship

- Achieve employee and public safety through the containment of electrical equipment within the enclosures and through the use of locks
- Impact employee and public safety due to rusted enclosures which can lead to holes in the enclosure exposing electrical equipment and defective hinges limiting the ability to quickly and safely access the underground switchgear
- Impact environmental stewardship by releasing oil or gas through asset failure

Asset Value

- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[4]

Resource Efficiency

- Achieve increased operating productivity through the use of remote operable underground switchgear connected to Hydro Ottawa's supervisory control and data acquisition system

Compliance

- Achieve compliance with the City of Ottawa's By-law No. 2008-01 – Graffiti Management through graffiti abatement program

In order to monitor and strive to improve the performance of distribution underground switchgear, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Underground Primary Switchgear KPIs

KPI	*Target*
SAIFI / 100 customers	0.98[5]
% of underground switchgear with health index information[6]	100%
% of underground switchgear with very poor health index score	0%

[4] Assumed based on resource and equipment requirements
[5] Based on a five (5) year average
[6] Asset health index KPI is based on timely data, that is, in line with the inspection cycle in GCS0015 *Thermographic Scanning of Power Lines and Distribution Apparatus*

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections on its underground switchgear. The information from the detailed inspections is used to calculate underground switchgear's health index through the Asset Condition Assessment (ACA) described in section 6.2. This includes assessing equipment and connection issues through infrared (IR) scanning. The detailed inspections are completed on a 3 year cycle where areas with older underground switchgear or known issues (such as leaking oil or gas, broken components) are prioritized. Due to the age, Hydro Ottawa has prioritized the detailed inspections of air insulated underground switchgear. Hydro Ottawa has detailed inspection information on 27%[7] of its distribution underground primary switchgear which results in health indexes shown in Figure 4 below using the ACA methodology, with plans to obtain health indexes on the remainder of distribution underground primary switchgear as per the targets in Table 5.

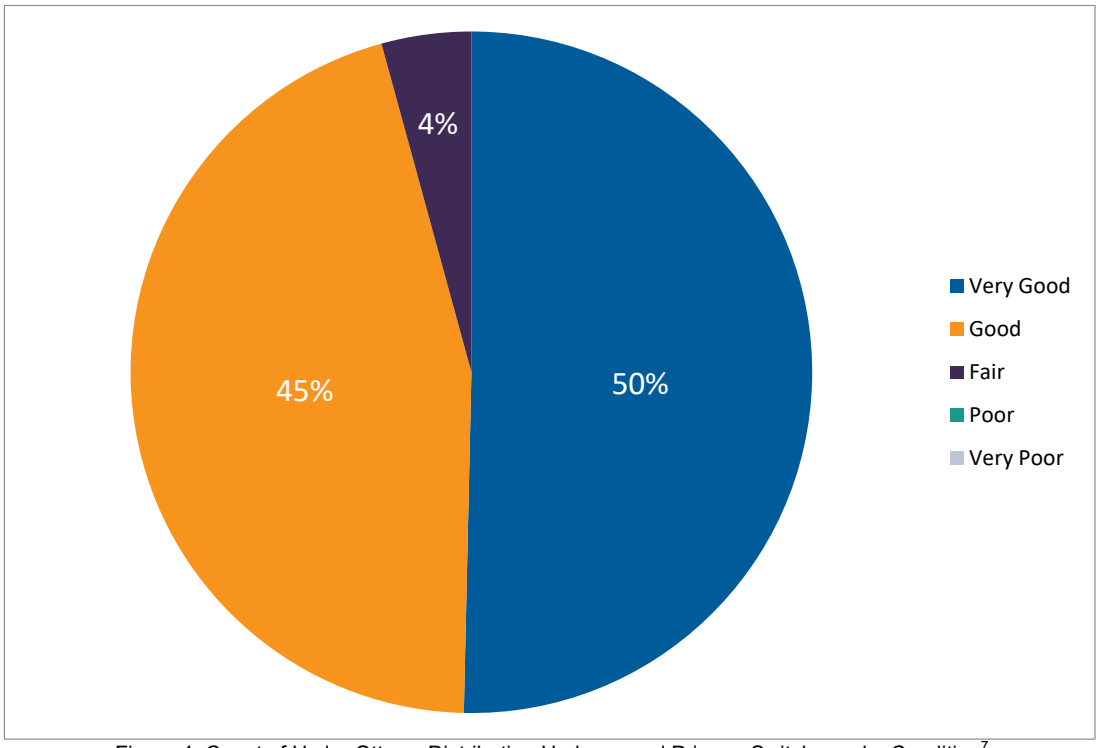


Figure 4: Count of Hydro Ottawa Distribution Underground Primary Switchgear by Condition[7]

Table 4: Distribution Underground Primary Switchgear Condition KPIs

KPI	Target	2018
% of underground switchgear with a health index score	**100%**	27%
% of underground switchgear with ACA compliant inspections with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of distribution underground switchgear with detailed inspection producing health index scores through ACAs shown in Table 4. The distribution underground switchgear inspection program was renewed in 2018 with an established detailed inspection cycle compliant to the ACA process for all underground switchgear. Hydro Ottawa plans to have inspection

[7] Information as of August 2019

information, including installation dates from equipment nameplates, to determine a health index for all distribution underground primary switchgear by 2021 (following the 3 year cycle) as shown in Table 5.

Table 5: Distribution Underground Primary Switchgear Inspection Plan

KPI	Target	2019	2020	2021
% of underground switchgear with health index information	**100%**	60%	94%	100%

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Table 6: Distribution Underground Primary Switchgear Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Underground switchgear - SAIFI / 100 customers	**0.98**	0.29	2.59	0.04	0.25	1.71

Hydro Ottawa does not currently meets the reliability target for outages due to defective distribution underground primary switchgear and will continue to monitor reliability metrics for trends and improvements.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades underground switchgear due to various drivers described in Table 7 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Underground switchgear are installed as per approved procedures and standards available in the Underground and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 7: Drivers for Underground Distribution Switchgear Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to alleviate capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. For underground switchgear these may include:

Customer Connections

- Upgrade an existing underground switchgear to support service equipment
- New underground switchgear installed to support service equipment
- New underground switchgear installed to support distribution underground conductors to expand Hydro Ottawa's system

Relocated Assets

- Relocate underground switchgear to accommodate work (e.g. new developments, road expansions) and eliminate clearance concerns



Figure 5: Underground Switchgear with Decorative Wrap

Table 8 shows the historical quantity of underground switchgear issued to the field for various activities under System Access; note the totals in the table do not include number of primary pedestals issued.

Table 8: System Access – Distribution Underground Primary Switchgear Installed / Replaced / Upgraded[8]

Description	2014	2015	2016	2017	2018
Customer Connection	5	22	18	9	11
Assets Relocated	2	0	0	4	1

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the distribution underground switchgear. Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through an underground switchgear failure. Hydro Ottawa replaces underground switchgear each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff through visual inspections, the ACA health index results from detailed inspections and feedback from third parties citing concerns. Table 9 shows the historical underground switchgear issued to the field for various activities under System Renewal.

Table 9: System Renewal - Distribution Underground Primary Switchgear Replaced / Upgraded[8]

Description	2014	2015	2016	2017	2018
Corrective Renewal	8	3	5	6	4
Planned Renewal	6	2	10	5	2
Assets Damaged by Third Parties	0	0	0	0	1

Corrective Renewal

Underground switchgear which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual, through IR scanning or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 10. Where applicable, the underground switchgear may be upgraded to align with future plans such as adding an operable way for a future underground conductor connection.



Figure 6: Hole in Underground Switchgear Enclosure

Table 10: Distribution Underground Primary Switchgear Corrective Renewal Criteria

Emergency Renewal (Immediate Risk)	Critical Renewal (Imminent Risk)
Damaged beyond repair	Dielectric breakdown / loss of dielectric
Inoperable	Irreplaceable component
Exposure of live components to public	Insufficient health index (very poor / < 30%)
Extreme corona detected	
Health index of 0%	

Planned Renewal
Underground switchgear which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews distribution underground switchgear's calculated ACA health index and underground switchgear in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's underground switchgear renewal program. Additionally, underground switchgear may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained.

Assets Damaged by Third Parties
Underground switchgear that are damaged due to third parties are replaced immediately after the area is made safe. Historically, this damage has been due to motor vehicle accidents or construction equipment.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by underground switchgear work, but may require underground switchgear to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects may include:

Voltage Conversion
- Reduce Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements
- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades
- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Underground switchgear are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope, in need to be replaced, upgraded or installed. Additionally, the condition of the underground switchgear is reviewed to determine if replacement due to end-of-life is anticipated. Underground switchgear may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 11 shows the historical underground switchgear issued to the field for various activities under System Service.

Table 11: System Service – Distribution Underground Primary Switchgear Installed / Replaced / Upgraded[8]

Description	2014	2015	2016	2017	2018
Voltage Conversion	0	1	0	0	0
System Reliability	1	1	3	2	1
System Capacity	2	3	0	1	2

6.2. Operations & Maintenance Plan

Underground Switchgear Inspection and Testing
Hydro Ottawa proactively performs both a visual inspection to report deficiencies and a detailed inspection to capture ACA information on the distribution underground primary switchgear. Hydro Ottawa's employees perform passive visual inspections on underground switchgear regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are reported by exception as per ESG0001 *Hydro Ottawa Electrical*

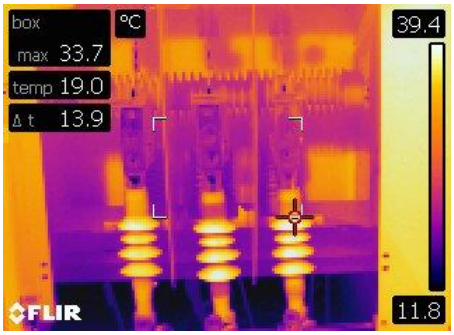


Figure 7: Underground Switchgear Infrared Scan

[8] Totals do not include quantities of primary pedestals issued

Distribution Safety Construction Verification Program in compliance with Ontario Regulation 22/04, so that the issue can be rectified. Hydro Ottawa also uses external contractors to perform thermographic scanning following GNG0001 *Guidelines for Thermography*. Issues found from this inspection are reported to Hydro Ottawa and actioned for remedy. Issues or deficiencies are also communicated to Hydro Ottawa per the working procedure GCS0033 *Dry Ice Blasting and Thermographic Inspection for Underground Distribution Switchgear* detailed below.

In the course of the thermographic scanning inspection a detailed inspection on underground switchgear following the working procedure UIS0002 *Padmounted Switchgear Inspection Procedure*. This information, along with the details from the thermographic scanning, is used to calculate the overall condition of underground switchgear by calculating a health index using the ACA formulation described in *GEG0001 Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the underground switchgear's condition. Hydro Ottawa historically has only completed detailed inspections for air-insulated underground switchgear; however, starting in 2019 detailed visual inspections will be completed for all underground switchgear. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections are used to determine the asset maintenance and renewal plans.

Underground Switchgear Repair

Hydro Ottawa performs proactive maintenance and reactive repair to underground switchgear when there are minor issues which don't classify the underground switchgear as reaching its end-of-life (through the inspection process mentioned above). This is primarily restricted to air-insulated underground switchgear as its construction enables access to the switchgear's internal components allowing Hydro Ottawa to perform scheduled maintenance and minor repairs as needed. Switchgear that use other dielectric mediums use hermetically sealed compartments which restrict access to the switchgear's components, thereby limiting the requirement for and ability to perform maintenance activities.

The primary maintenance activity carried out on air-insulated underground switchgear is CO_2 washing. This is completed by Hydro Ottawa contractors in order to remove contamination, such as road salt, that contributes to tracking and flashover causing loss of power, equipment damage and misrepresented thermographic results. The carbon dioxide is mixed with clean compressed air at the spraying nozzle and safely removes surface contamination from both energized and de-energized internal equipment. CO_2 washing allows switchgear to be cleaned while energized, is environmentally friendly, safe and leads to increased system reliability.



Figure 8: Underground Switchgear C02 Washing

Vault Switchgear Inspection and Maintenance

Hydro Ottawa provides direction for the detailed inspection and maintenance on vault switchgear and other vault equipment as described in VIS0001 *Electrical Equipment Vault Inspection and Maintenance*. This document generally describes the inspection cycle and various ownership arrangements of vaults, the inspections and testing to be performed, how to prepare electrical equipment for maintenance, typical maintenance activities and restrictions for working within vaults.

Graffiti Abatement

Hydro Ottawa utilizes contractors to inspect and remedy underground switchgear that have graffiti or rusted enclosures. This program was developed in response to the City of Ottawa Graffiti By-Law No. 2008-01 – Graffiti Management to ensure Hydro Ottawa keeps its property free of graffiti. It also allows Hydro Ottawa to work cooperatively with the City of Ottawa By-Law department to address criminal acts of graffiti to deter future acts of vandalism.



Figure 9: Underground Switchgear Graffiti Removal, before and after

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses distribution underground primary switchgear depending on their condition when they are removed from service. Hydro Ottawa only re-uses underground switchgear following testing and inspection as per the previously mentioned inspection methods and WSS0015 *Testing S&C Vista Switchgear* and referencing ANSI/NETA MTS-2015. Where an underground switchgear is permanently removed from service, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. Insulation mediums are disposed of based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of distribution underground primary switchgear which that are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 10. This stock allows Hydro Ottawa to replace such underground switchgear in a timely manner minimizing the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of 10 underground switchgear of various configurations, voltages and insulation type to be used during emergencies. Additionally, Hydro Ottawa stocks numerous quantities of various types of underground switchgear components. The minimum quantity of underground switchgear is based on the asset's usage and the need to have replacements should an emergency occur.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of underground transformers should an issue arise or more assets be required. Additionally, this includes using contractors to assist Hydro Ottawa in asset installation during emergencies.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual underground switchgear to be installed, replaced or upgraded under System Access are shown in Table 12.



Figure 10: Underground Switchgear Installation

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms (e.g. Public Service Works on Highways Act).

Table 12: Forecasted System Access - Distribution Underground Primary Switchgears Installed/Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	13	13	13	13	13	13	13
Assets Relocated	1	1	1	1	1	1	1

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by assets reaching end of life based on information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue with existing inspections and increase the scope to cover all insulation sub-classes beginning in 2019. This may increase the number of switchgear found to be at end-of-life. However, based on the known ages of non-air insulated underground switchgear, Hydro Ottawa does not expect an increase in underground switchgear replaced through corrective renewal and thus forecasts the future replacement based on historical averages. Underground switchgear replaced due to assets damaged by third parties are forecasted based on historical averages.

Hydro Ottawa plans to proactively replace underground switchgear in a poor condition (health index score of >=30% and < 50%) through detailed inspections. Additionally, Hydro Ottawa plans to replace the remaining air-insulated switchgear, over a 10-year period, beginning in 2021 to reduce risks to the asset management objectives. As air-insulated switchgear are among the oldest and worst condition underground switchgear assets, it is expected that these replacement drivers will overlap. This will also reduce and eventually eliminate the ongoing operation and maintenance costs associated with carbon dioxide (CO_2) washing. This proactive replacement also strives to levelize the replacement of underground switchgear over their 25 year expected operation life. This levelization allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual underground switchgear to be replaced or upgraded under System Renewal are shown in Table 13.

Table 13: Forecasted System Renewal – Distribution Underground Primary Switchgear Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal**	5	5	5	5	5	5	5
Planned Renewal	3	5	4	4	4	4	4
Assets Damaged by Third Parties**	0	0	0	0	0	0	0

*Estimated Quantities
**Based on 5 year historical data ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require distribution underground switchgear to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for underground switchgear under System Service is shown in Table 14.

Table 14: Forecasted System Service – Distribution Underground Primary Switchgear Replaced/Upgraded/Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	0	0	0	0	0	0	0
System Reliability	0	0	0	0	0	0	0
System Capacity	3	0	1	0	0	0	0

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact distribution underground primary switchgear and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to underground switchgear. While more resilient than overhead construction, freezing rain, ice storms and high wind events have the capacity to exceed the underground switchgear's design limits and lengthen the time to access the equipment to perform switching. These events can lead to damaged assets and a reduction in Hydro Ottawa's levels of service. Additionally, increased flooding and ingress of water into energized equipment can negatively affect public and employee safety, damage equipment and cause outages, negatively affecting Hydro Ottawa's levels of service. Flooding is not expected to affect gas insulated underground Vista switchgear, as severely as air insulated underground switchgear, as the internal components are within a hermetically sealed enclosure and the underground cable terminations use elbow connections.



Figure 11: October 2017 Flooding

Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to underground switchgear, and there are no current climate specific adaptations for this asset. This assessment will be periodically reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. underground switchgear renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. underground) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Distribution underground primary switchgear assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 25 years. The difference between the expected operating life and the financial useful life is that certain drivers require underground switchgear to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project. Currently, the expected operating life and financial life for underground switchgear are the same.

The existing net book value of Hydro Ottawa's distribution underground primary switchgear is approximately $11.6M[9] which represents 1.7% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy* (i.e. straight line depreciation); therefore, the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's distribution underground primary switchgear is approximately $3.2M[9].

[9] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of distribution underground primary switchgear in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with underground switchgear.

Hydro Ottawa also addresses issues with distribution underground primary switchgear through the underground standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to underground assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions. Hydro Ottawa is currently working to determine the feasibility of a new solution to repair holes in padmounted equipment enclosures. The ability to repair the corroded equipment may allow Hydro Ottawa to achieve the asset management objectives in a more economic method.

Hydro Ottawa also supports smart grid investments and has replaced several end-of-life underground switchgear with smart, Supervisory Control and Data Acquisition (SCADA) controlled switchgear. These SCADA controlled assets allow for remote operation of the switch, thus achieving resource efficiencies by reducing crew and truck time previously required for switching. They also support improvement to Hydro Ottawa's levels of service by reducing the time of outages through the operational efficiency.



Figure 12: Underground Switchgear with Remote Operable Control and Communications Cabinet

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution underground primary switchgear achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0003**	REV: **2**
APPROVED:	L. Heuff		
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Asset Management Plan
Station Transformers

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-13	cm/gp/jm
1	Addressed gaps defined in AMPs – Outstanding Items – R0-2 General Content Update	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



Asset Management Plan – Station Transformers

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1. Introduction

Hydro Ottawa's station transformers are used to modify voltage levels for distribution and to supply electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa - Strategic Direction
Hydro Ottawa - *Distribution System Plan*
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management System Plan*
Hydro Ottawa - STS0007 - *Oil Sampling and Analysis of Station Transformers and Tap Changers*
Hydro Ottawa - SIP0001 - *Station Inspection, Resolution, and Tracking Process*
Hydro Ottawa - SIP0002 - *Transformer Testing and Inspection Procedure*
Hydro Ottawa - SIP0004 - *Station Transformer Dissolved Gas Analysis*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - GNG0001 - *Guidelines for Thermography*
Hydro Ottawa - E&O intranet website - *Stations Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Stations Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Stations Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Stations Qualifications*
Hydro Ottawa - E&O intranet website - *Stations Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Stations Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Stations Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001
Government of Canada - SOR/2008-273 - *PCB Regulations*

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's station transformer assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of a station transformer can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to station transformer includes the components below which allow for the successful use of the asset.

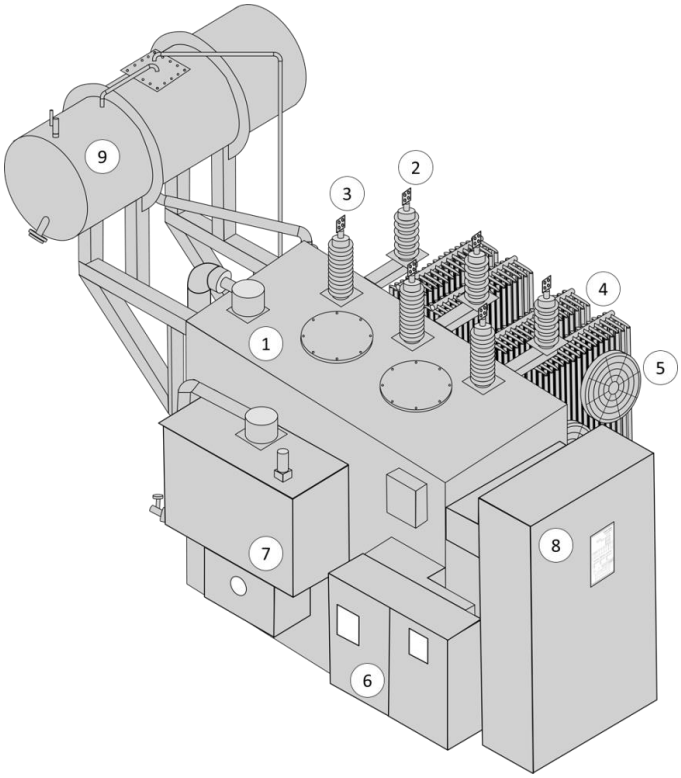


Figure 1: Station Transformer System (Illustrative Purposes Only)

Table 1: Station Transformer Functions

Figure Number	Component	Function
1	Enclosure (main tank)	The station transformer enclosure maintains isolation of the high and/or medium voltage components from outside sources, while ensuring security from the public for increased safety. Additionally, the enclosure protects the inner components of the transformer from damage, and by isolating it from weather, animals and contaminants.
2	Surge Arrestors	Station surge arresters protect the system and equipment by supressing voltage surges from various causes (e.g. lightning).
3	Bushings	Station transformer bushings support an insulated flow of current from the connecting conductors (not shown) to the inner components through the grounded enclosure.

Figure Number	Component	Function
4	Radiators	The radiators support the asset's successful operation by cooling the oil using natural convection. As warm oil flows into the top the radiators, cooler oil flows back into the transformer through the bottom. The management of station transformer temperature is vital to ensuring it can support the designed transformation capacity without degrading internal components over its lifecycle.
5	Fans	The cooling fans further support the oil cooling mentioned above as the fanned air cools the oil as it travels down through the radiators. These fans allow a station transformer to achieve increased electrical transformation capacity by managing its temperature. Fans are typically controlled on and off through relays at specific temperature thresholds.
6	Control Cabinet	A station transformer's control cabinet encloses and protects various monitoring and protection systems (described below) from damage by physically isolating it from weather, animals, contamiants and the public.
7	Tap Changer	The on-load tap changer is used to regulate the voltage of the station transformer by changing the transformer's winding ratio. The tap changer can rotate up or down to either increase or decrease the ratio. This ensures that the voltage supplied by the station is constant, even in cases where the incoming voltage is too high or too low. This results in high-quality power being distributed from the station into the distribution network.
8	Bushing Enclosure	The bushing enclosure is used on station transformers with side-mounted bushings (not shown), which are typical for connecting underground conductors (not shown). The bushings and cables are contained within the metal enclosure, which protects them from the outdoor elements described by the station transformer enclosure above.
9	Conservator	The conservator tank provides space for a station transformer's oil (not shown) to expand and contract as the transformer's load increases and decreases. When the electrical load increases, the transformer's temperature rises, causing the oil to expand into the conservator tank. When the load decreases, the temperature decreases, causing the oil to contract and flow down from the conservator into the main tank. This separation also ensures oxidization occurs in the conservator and not in the main transformer tank. There are some transformers in Hydro Ottawa's system that are fully sealed, and do not use a conservator tank.
Not Shown	Monitoring and Protection Systems	Monitoring and protection systems are used to ensure that a station transformer operates to its full expected life safely. Various sensors are used to measure temperature, gas accumulation and pressure. The results control cooling systems on the transformer, signal alarms to system operators and operate breakers to isolate and protect the transformer. Additionally, the results are used to drive maintenance or renewal activities.
Not Shown	Online Dissolved Gas Analyzer	Online dissolved gas analyzers continuously monitor gas accumulation in the station transformer's oil to ensure operation over its lifecycle. If a transformer experiences a fault, various gases accumulate in the transformer oil. Tracking the rate of change of these gases can provide an early indication of developing faults in a transformer.
Not Shown	Core, Windings, Oil	A station transformer's core, primary and secondary windings and oil insulation are sealed within the transformer's enclosure. These elements work together to convert supplied electricity from a high or medium voltage to outgoing electricity at a lower voltage through the use of electrical and magnetic induction. This allows for electricity to be stepped down from a transmission or sub-transmission voltage to a distribution voltage for economic delivery throughout Hydro Ottawa's service territory.

Table 2: Class, Sub-class and Components of Station Transformers

Class	*Sub-Class*	*Components Belonging to or Supporting the Sub-Class*
Station Transformer	Conservator	Enclosure, Core, Windings, Bushings, Arrestors, Paper Insulation, Insulating Oil, Cooling Radiators, Tap Changer, Monitoring and Auxiliary/Protection Equipment, Pressure Relief Valve, Conservator Tank, Breather
	Sealed	Enclosure, Core, Windings, Bushings, Paper Insulation, Insulating Oil, Cooling Radiators, Tap Changer, Monitoring and Auxiliary/Protection Equipment, Pressure Relief Valve

Station transformers form one of Hydro Ottawa's most critical asset classes due to the ability to affect thousands of customers. Hydro Ottawa owns 167[2] which operate at various voltages, connected to either Ontario's electric transmission grid or connected to the local sub-transmission system. Hydro Ottawa also supplies distribution stations and customers through 37[2] station transformers owned and maintained by Hydro One Network Inc (HONI). Hydro Ottawa does not actively manage HONI-owned station transformers.

Figure 2 shows the various operating primary voltage levels founds within Hydro Ottawa's service teritory. Currently, Hydro Ottawa has installation dates stored in the Geographic Information System (GIS) for 100%[2] of its station transformers. The overall age demographics of station transformers is shown in Figure 3 and shows the average age of this asset class to be 35[2] years. The expected operating life of station transformers, where probability of failure is approximately 1.5% or greater, is an effective age of 55 years[3]. There are seven (7) station transformers that have reached the expected service age and 86[2] will reach it within 10 years.

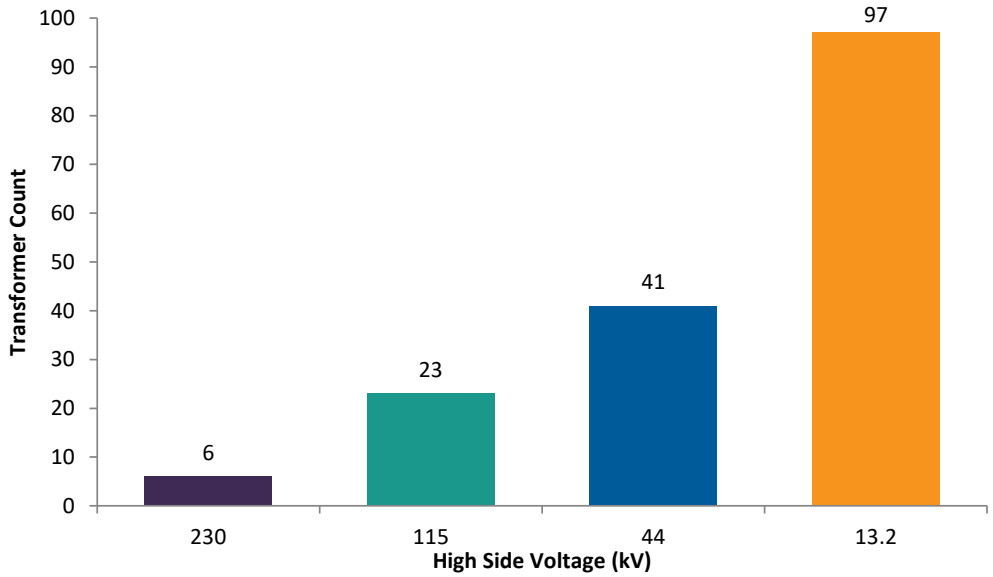


Figure 2: Hydro Ottawa's Station Transformer High Voltage Supply[4]

[2] Information as of December 2018
[3] METSCO Energy Solutions - Asset Health & Risk Assessment Method R1
[4] Information as of April 2018

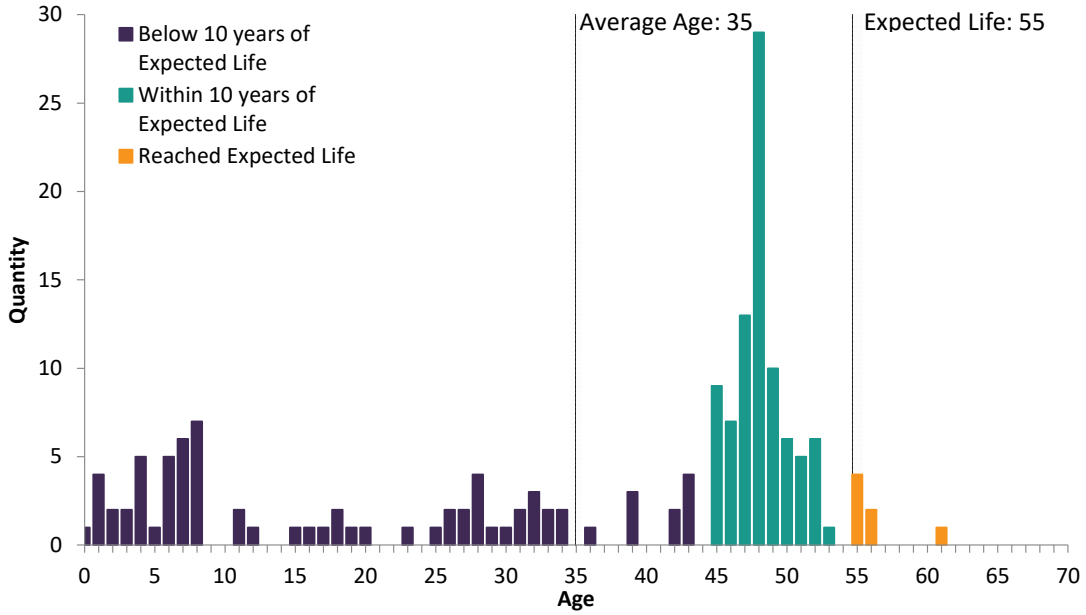


Figure 3: Hydro Ottawa's Station Transformer Age Demographics[4]

4. Asset Management Objectives

Station transformers require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Achieve transformation of electricity to be used by other assets to distribute to customers
- Impact on service reliability due to an electrical interruption affecting a large number of customers supplied by the transformer
- Achieve good power quality through the use of tap changers

Health, Safety & Environmental Stewardship

- Achieve employee and public safety through the containment of electrical equipment within the enclosure and through the use of fencing and locks
- Impact employee and public safety due asset failure
- Impact environmental stewardship by releasing oil or gas through asset failure

Asset Value

- Achieve reduced costs from equipment amalgamation or elimination
- Impact asset lifecycle cost, as an emergency replacement is more costly than planned replacement[5]

Resource Efficiency

- Impact resource optimization, as a single emergency replacement is less efficient than planned replacement which may include the replacement of additional transformers and other station equipment[5]

Compliance

- Impact compliance with the Government of Canada - SOR/2008-273 - PCB Regulations

In order to monitor and strive to improve the performance of station transformers, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Station Transformer KPIs

KPI	*Target*
Station transformer - SAIFI / 100 Customers	0.93[6]
% of station transformers with health index information[7]	100%
% of station transformers with very poor health index score	0%

[5] Assumed based on resource and equipment requirements and economies of scale
[6] Based on a five (5) year average
[7] Asset health index KPI is based on timely data, that is, in line with the inspection cycle in OIS0005 – Overhead Line Inspection Method

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspection and testing on its station transformers. The information from the inspections and testing are used to calculate station transformer's health index through the Asset Condition Assessment (ACA) described in section 6.2. The detailed inspections are completed at varying prescribed frequencies based on inspection task and equipment characteristics detailed in SIP0002 *Transformer Testing and Inspection Procedure*. Hydro Ottawa has detailed inspection information on 100%[8] of its station transformers which results in health indexes shown in Figure 4 below using the ACA methodology.

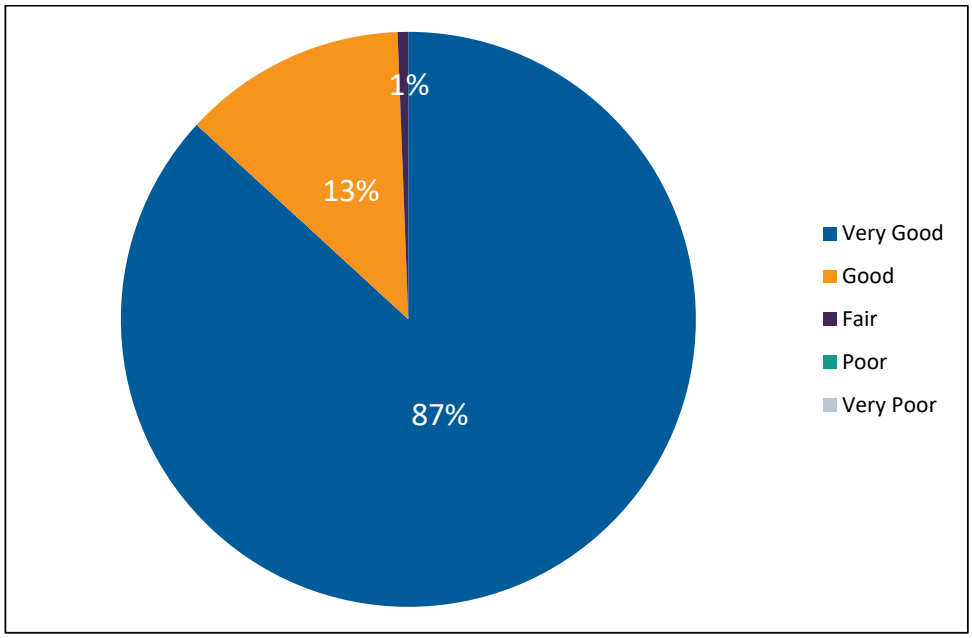


Figure 4: Count of Hydro Ottawa Station Transformers by Condition

Table 4: Station Transformer Condition KPIs

KPI	Target	2018
% of station transformers with a health index score	**100%**	100%
% of station transformers with a very poor health index score	**0%**	0%

Hydro Ottawa currently does meet the target of station transformers with detailed inspection producing health index scores through ACAs shown in Table 4. The station transformer inspection program was renewed in 2016 with an established detailed inspection cycle compliant to the ACA process. Information from historical inspections and new inspections has allowed Hydro Ottawa to understand the condition of its station transformers.

[8] Information as of August 2019

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Table 5: Station Transformer Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Station transformer - SAIFI / 100 customers	**0.93**	0.15	0.65	1.46	0.20	2.20

Hydro Ottawa does not currently meet the reliability target for outages due to defective station transformers and will continue to monitor reliability metrics for trends and improvements.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades station transformers due to various drivers described in Table 6 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Station transformers are installed as per approved procedures and standards available in the Stations and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 6: Drivers for Station Transformer Installations / Replacement / Removals

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. For station transformers these may include:

Customer Connections

- Upgrade an existing station transformer(s) to support service equipment
- New station transformer(s) installed to support service equipment

Table 7 shows the historical station transformers issued to the field for various activities under System Access.



Figure 5: Station Transformer - Borden Farms Substation

Table 7: System Access – Station Transformers Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	0	0	0	0	0

While uncommon, Hydro Ottawa has been approached by customers with significant electrical loads which would require station transformers to be upgraded. Hydro Ottawa does not consider station transformers upgraded for capacity reasons due to general load growth to be categorized under System Access, but rather single party requests deemed to be above and beyond normal customer load.

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of station transformers. As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a station transformer failure. Hydro Ottawa replaces station transformers each year based on feedback from Hydro Ottawa staff through visual inspections and the ACA health index results from detailed inspections. Table 8 shows the historical station transformers, based on manufacture date or historical spending, issued to the field for various activities under System Renewal.

Table 8: System Renewal – Station Transformers Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	2018
Corrective Renewal	0	1	0	1	0
Planned Renewal	5	0	2	1	3
Assets Damaged by Third Parties	0	0	0	0	0

Corrective Renewal
Station transformers which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual during monthly station inspections or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 9. As part of corrective renewnal, an adequacy review is performed and the station transformer size may increased or decreased to align with future capacity planning, if achievable.

Table 9: Station Transformer Corrective Renewal Criteria

Emergency Renewal (Immediate Risk)	*Critical Renewal (Imminent Risk)*
Internal fault	Tap-changer failure
Bushing failure	Heavy gassing
Tank rupture (loss of oil)	Overheated bushing (found with IR scan)
Major issue found during maintenance	High furan level
Health index of 0%	Significant issues found in testing
	Insufficient health index (very poor / < 30%)

Planned Renewal
Station transformers which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews station transformer's calculated ACA health index. Station transformers in a poor state (health index score of < 50%) are planned for replacement in Hydro Ottawa's station transformer renewal program. Additionally, station transformers may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained. Hydro Ottawa actively reviews other station assets and where additional poor condition assets exist may replace all assets under the station major rebuild program.

Assets Damaged by Third Parties
Station transformers which are damaged due to third parties are replaced immediately after the area is made safe. Historically, due to the access restrictions and protective enclosures such as fencing or buildings, this is rare for station assets.



Figure 6: Rusted Station Transformer Radiator

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by station transformer work, but may require station transformers to be installed, upgraded or replaced to accomplish the identified objectives. The primary driver which affects station transformers is capacity improvements. Projects under this driver aim to improve Hydro Ottawa's system accessibility for load and energy by removing capacity constraints.

Station transformers may be replaced before their end-of-life based on technical requirements or overall economic efficiencies to accommodate System Service projects. Table 10 shows the historical station transformers issued to the field under System Service.

Table 10: System Service – Station Transformers Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	2018
Capacity	0	0	0	1	1

6.2. Operations & Maintenance Plan

Station Transformer Inspection and Testing
Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and a detailed inspection to capture ACA information on station transformers. Hydro Ottawa employees perform visual inspections on station transformers on a monthly or bi-monthly basis. Visual condition and deficiencies are reported as described in the working procedure SIP0001 *Station Inspection, Resolution, and Tracking Process* so it can be rectified.



Figure 7: Station Transformer Inspection

Hydro Ottawa also completes a detailed inspection and testing on station transformers following the operating procedure SIP0002 *Transformer Testing and Inspection Procedure*. This procedure also details the time frames for the various tests to be performed. The testing and inspections completed on station transformers include:

- Oil testing
- Insulation resistance
- DC winding resistance
- Turns ratio
- Exciting current
- Insulation power factor
- Thermographic surveys

Specifically for oil testing, dissolved gas analysis is completed following the work procedure SIP0004 *Station Transformer Dissolved Gas Analysis*. Additionally, oil sampling is completed following the general procedure STS0007 *Oil Sampling and Analysis of Station Transformers and Tap Changers*.

This information is used to calculate the overall condition of station transformers by calculating a health index using the ACA described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the station transformer's condition. Results from inspections are stored in Hydro Ottawa's station maintenance software. The information provided through inspections can be used to determine the asset maintenance and renewal plans.

Station Transformer Repair
Hydro Ottawa performs maintenance and repair to station transformers when there are minor issues which don't classify the station transformer as reaching its end-of-life (through the inspection process mentioned above).

Hydro Ottawa performs proactive maintenance to station transformers through cleaning and torquing (tightening) connections to ensure proper fitting and assembly between parts. Hydro Ottawa also completes reactive maintenance through corrective repairs to power transformers.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses station transformers depending on their condition when they are removed from service due to various drivers. While re-using station transformers is rare, it is occasionally required to support a failed asset or if a good condition asset is no longer required and can be used to replace a worse condition asset. In the case of re-using station transformers, detailed inspections are required to ensure the asset is in proper working order after transportation following the inspections detailed in Section 6.2, and transformer reintroduction into the distribution system is handled on a case by case basis. Where a station transformer is decommissioned, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. Insulation mediums are disposed of based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa does not maintain a stock of spare station transformers. The potential need for these assets during emergencies can arise from the drivers described in Table 9. Additionally, maintenance of a station transformer may require taking it out of service. The majority of Hydro Ottawa's substations include two station transformers to ensure redundancy due to the criticality of this asset class. In addition to redundant transformers and for substations with a single transformer, distribution connection ties, through the use of overhead and underground conductor and switches, are utilized during emergencies to ensure the electrical system continues to be available to customers.

In the scenario where a station transformer is removed from service due to maintenance or failure for an extended amount of time, further contingency plans are developed by the System Operations and Asset Planning section with input from various stakeholders. This can include significant system switching to transfer customers to other supply sources and operating station equipment above normal operating limits, but below equipment damage thresholds.



Figure 8: Multiple Station Transformers at Bronson Substation

7. Future Demand

7.1. System Access

System Access work is requested by third parties and it is therefore difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. It is uncommon that Hydro Ottawa replaced a station transformer due to drivers under System Access.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms e.g. Public Service Works on Highways Act.

Table 11: Forecasted System Access – Station Transformers Installed / Replaced / Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	0	0	0	0	0	0	0

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by assets reaching end of life based on information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue the constant monitoring, health index updates, inspections and maintenance of station transformers. While Hydro Ottawa has had station transformers fail, and thus be replaced reactively in the past, Hydro Ottawa forecasts no station transformers to be replaced under corrective renewal due to the continued testing, inspection and maintenance program. Station transformers replaced due to assets damaged by third parties are forecasted based on historical averages.



Figure 9: Installation of new Station Transformer

Hydro Ottawa plans to proactively replace poor condition (health index score of < 50%) station assets. These are identified through detailed inspections and maintenance. Additionally, due to the risk posed by the number of station transformers in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined the number of station transformers which require proactive replacement to mitigate the risk. This replacement strategy will prioritize station transformers based on their ACA results, as well as levelize the future replacement of the growing and aging fleet of assets. This levelization allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual station transformers to be replaced or upgraded are shown in Table 12. Planned renewal numbers reflect that Hydro Ottawa will not be replacing all end of life transformers, for reasons such as voltage conversion, therefore reducing the total number station transformer assets owned by Hydro Ottawa. Additionally, due to the generally good health score of aging station transformers, the period of replacement over which the replacement program is levelized has been extended appropriately.

Table 12: Forecasted System Renewal – Station Transformers Replaced / Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Planned Renewal	5	0	2	0	3	2	1
Assets Damaged by Third Parties	0	0	0	0	0	0	0

*Estimated Quantities

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require station transformers to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for station transformers is shown in Table 13.

Table 13: Forecasted System Service – Station Transformers Replaced / Upgraded / Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
System Capacity	1	0	3	2	0	0	2

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact station transformers and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose significant threat to station transformers. One of the main impacts affecting station transformers is rising temperatures. During the summer months where system electricity demand is already the highest compared to the rest of the year, increased heat and corresponding electrical responses, such as air conditioning, can put strain on system equipment including station transformers. An increasing occurrence of high heat conditions, coupled with continued electrical demand growth can strain and limit supply capacity of these assets. Constant and timely system and asset monitoring and forecasting are required to ensure station transformers continue to operate safely and provide value through delivering the asset management objectives.

Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to station transformers, and there are no current climate specific adaptations for this asset. This assessment will be periodicly reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. station transformer renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. stations) and the respective program cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Station transformer assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a discrete method, due to their quantity, price and limited number, over their expected financial useful life of 45 years. The difference between the expected operating life and the financial useful life is that certain drivers require station transformers to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's station transformers is approximately $58.1M[9] which represents 8.5% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy*, e.g. straight line depreciation. Therefore the assets depreciate annually over their expected financial useful life. The accumulated depreciation of Hydro Ottawa's station transformers is approximately $8M[9].

[9] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of station transformers in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure AMS Risk Procedure* will be used to address fundamental risks and opportunities with station transformers.

Hydro Ottawa also addresses issues with station transformers through the stations standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to station assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

Hydro Ottawa has introduced the utilization of online dissolved gas analyzers (ODGA) for station transformers. The online capabilities of the analyzers allow Hydro Ottawa to obtain more timely monitoring, reduce resource requirements associated with laboratory oil sampling and testing and instant notification of elevate gas levels. This information enables Hydro Ottawa to relate gassing to external/internal events providing greater detail on potential causes and the opportunity to prevent outages or further damage before they occur. Hydro Ottawa installs various types of ODGAs depending on the size and voltage class of the transformer to align cost with benefits following SIP0004 *Station Transformer Dissolved Gas Analysis*.

Additionally Hydro Ottawa is reviewing new ways to monitor station transformer oil temperatures. Technical issues have been identified with the existing monitoring techniques and therefore a trial of new resistance temperature detectors (RTD) is being initiated. These temperature monitors will allow for oil temperature monitoring on every station transformer at the top and bottom of the tank. The monitors will also provide signals to drive the cooling fan controller when the temperature exceeds a defined temperature to achieve successful continued operation.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections who are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the IAP-0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to station transformers achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0004**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Station Switchgear & Breakers

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-05	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



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1. Introduction

Hydro Ottawa's station switchgear and breaker assets are used to support the delivery electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall Asset Management objectives and associated measures as described in the SAMP. The AMP describes the current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - SIP0001 - *Station Inspection, Resolution, and Tracking Process*
Hydro Ottawa - SIP0003 - *Station Switchgear and Breaker Testing and Maintenance Procedure*
Hydro Ottawa - WSS0012 - *Testing SF6, Oil, and Air Circuit Breakers*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - GNG0001 - *Guidelines for Thermography*
Hydro Ottawa - E&O intranet website - *Stations Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Stations Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Stations Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Stations Qualifications*
Hydro Ottawa - E&O intranet website - *Stations Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Stations Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Stations Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's station switchgear and breaker assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of station switchgear and breakers can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to station switchgear and breakers includes the components below, which allow for the successful use of the asset.

Station switchgear provide value by housing breakers and auxiliary equipment, as well as providing physical protection and isolation from potential explosions or fires should a breaker fail. Station breakers provide value by allowing for the ability to electrically isolate equipment, shift load, and to interrupt fault current. This allows the power to be distributed safely throughout the system, while ensuring that other equipment is protected from faults.

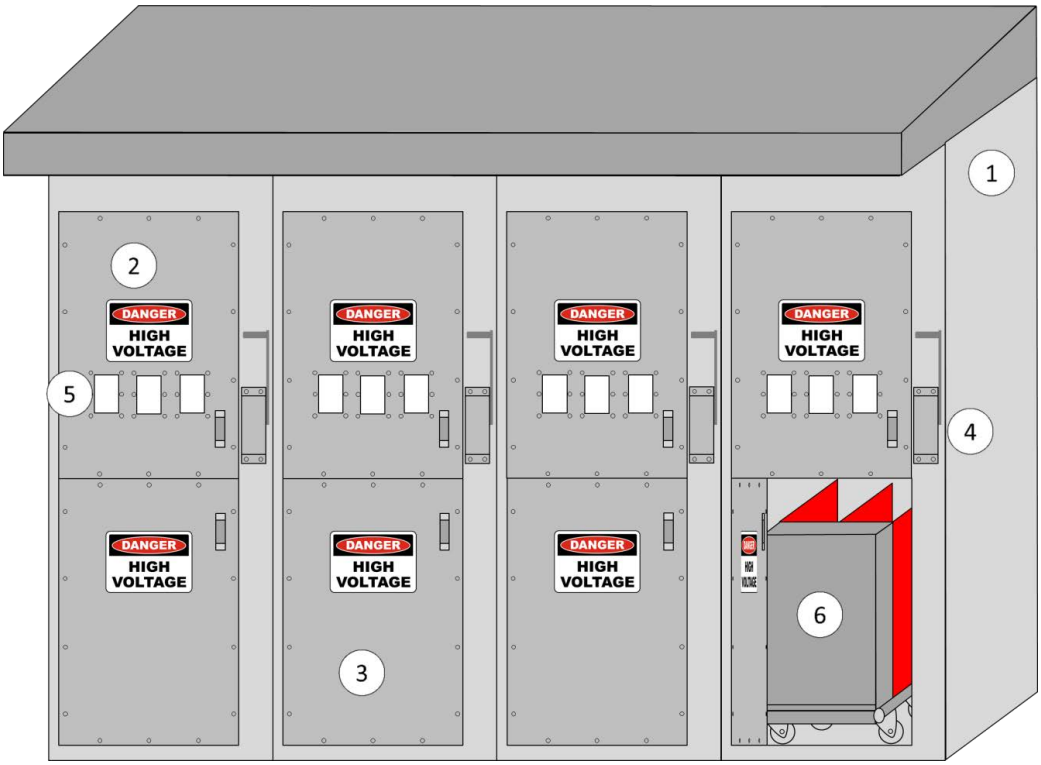


Figure 1: Station Switchgear and Breakers (Illustrative Purposes Only)

Table 1: Station Switchgear and Breakers Functions

Figure Number	Component	Function
1	Enclosure/Plenum	Enclosures maintain isolation of the medium voltage and high voltage equipment from outside sources and provide a barrier between energized equipment and the persons at the station. Additionally, the enclosure protects the inside equipment from damage. Finally, the enclosure houses the insulation, bus bars, switches, breakers, control cabling and isolation pieces of the switchgear. The plenum is part of the arc resistant design of a switchgear, which servces to stragetically direct and contain the forces associated with an arc flash to avoid catastrophic failure of the enclosure of the switchgear.
2	Control Cabinet	The control cabinet houses all of the low voltage and control signals, such as instrument transformer feedback, that are used to operate and provide communication signals from breakers.
3	Breaker Door	The breaker door isolates the breaker from the medium voltage equipment and provides a mechanism for removing breakers for isolation from the attached bus.
4	Breaker Switch	The breaker switch is used to open and close the circuit breaker's connection to the bus, housed within the switchgear.
5	Switchgear Window	Breaker windows allow a view into the switchgear enclosure for inspection and to visually identify connected or disconnected breakers.
6	Circuit Breaker	The circuit breaker is a protection and isolation device used to connect an electrical bus to a feeder or another electrical bus. Circuit breakers are rated for a specific current at which they will open, breaking load, as a protection device. The circuit breaker can be activated locally or remotely, and via other protective relays that can be wired into the control cabinet and breaker trip circuit.

Table 2: Class, Sub-class and Components of Station Switchgears and Breakers

Class	*Sub-Class*	*Components*
Station Switchgear	Open Bus	Bus Bar, Connections, Enclosures for Breakers and Control Cabinets
	Dog House	Enclosure, Bushings, Bus Cell, Auxiliary and Control Equipment Cell, Breaker Cell
	Metal-Enclosed	Enclosure, Bus Cell, Auxiliary and Control Equipment Cell, Breaker Cell
	Metalclad	Explosion-Proof Enclosure, Drawout Mechanism, Shutters, Bus Insulation, Bus Cell, Auxiliary and Control Equipment Cell, Breaker Cell
Station Breakers	Oil	Oil tank, Contacts, Actuator Mechanism, and additional parts
	Air	Puffers, Arc Chutes, Contacts, Actuator Mechanism, and additional parts
	Gas (SF6)	SF6 Cylinder, Contacts, Actuator Mechanism, and additional parts
	Vacuum	Vacuum Cylinder, Contacts, Actuator Mechanism, and additional parts

Hydro Ottawa owns 1,105[2] station breakers in 85 substations throughout the service territory, and does not discretely count the number of switchgear assemblies (switchgear are inherently maintained on a per cell basis as part of breaker maintenance). The majority of Hydro Ottawa's station breakers use air as their dielectric medium, and to a lesser extent, oil, gas (SF6) and vacuum. The demographics of these sub-classes are shown in Figure 2.

[2] Information as of December 2019

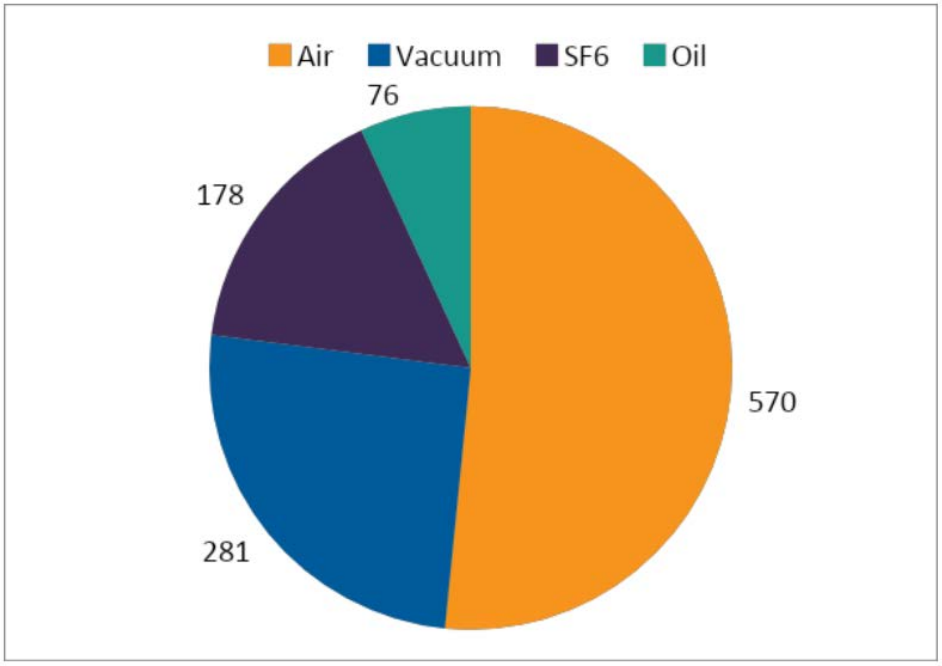


Figure 2: Hydro Ottawa's Station Breaker Sub-Class[2]

Currently, Hydro Ottawa has known and estimated purchase dates or installation dates stored in the Geographic Information System (GIS) for 88%[2] of its station breakers. The overall known age demographics of station breakers in the distribution system are shown in Figure 3. The expected operating life of station breakers, where the probability of failure is approximately 1.5% or greater, is shown in Table 3 for the station breaker sub-classes. In Figure 3-6, breaker demographics are plotted with respect to their expected life.

Table 3: Station Breaker Sub-Class & Expected Life

Sub-Class	Expected Life
Air	42
Oil	55
Vacuum	46
Gas (SF6)	51

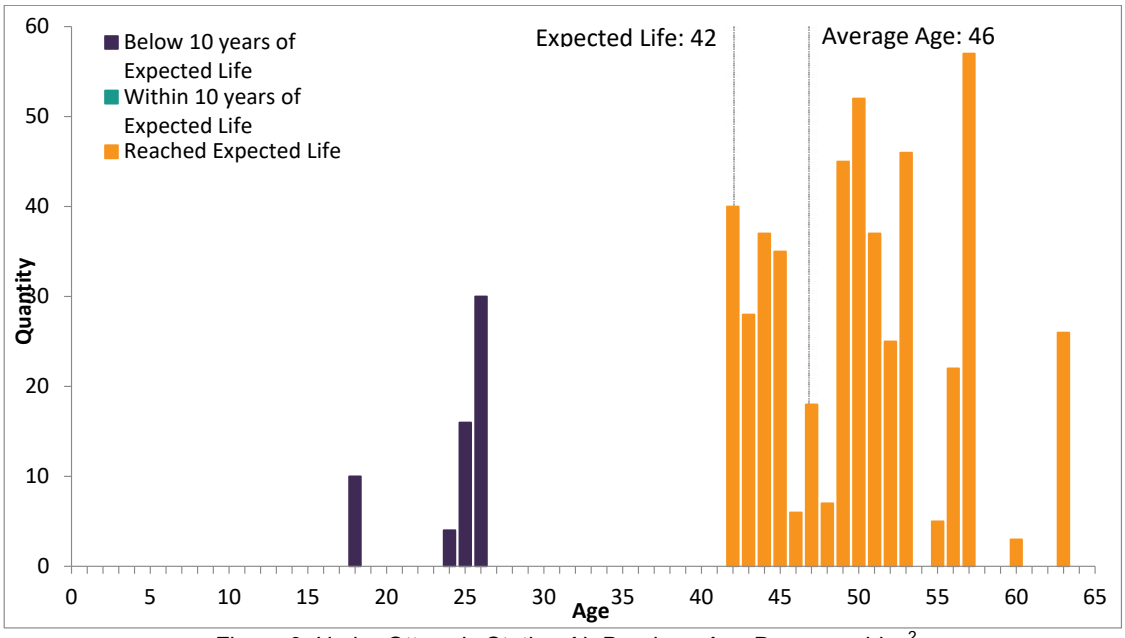


Figure 3: Hydro Ottawa's Station Air Breakers Age Demographics[2]

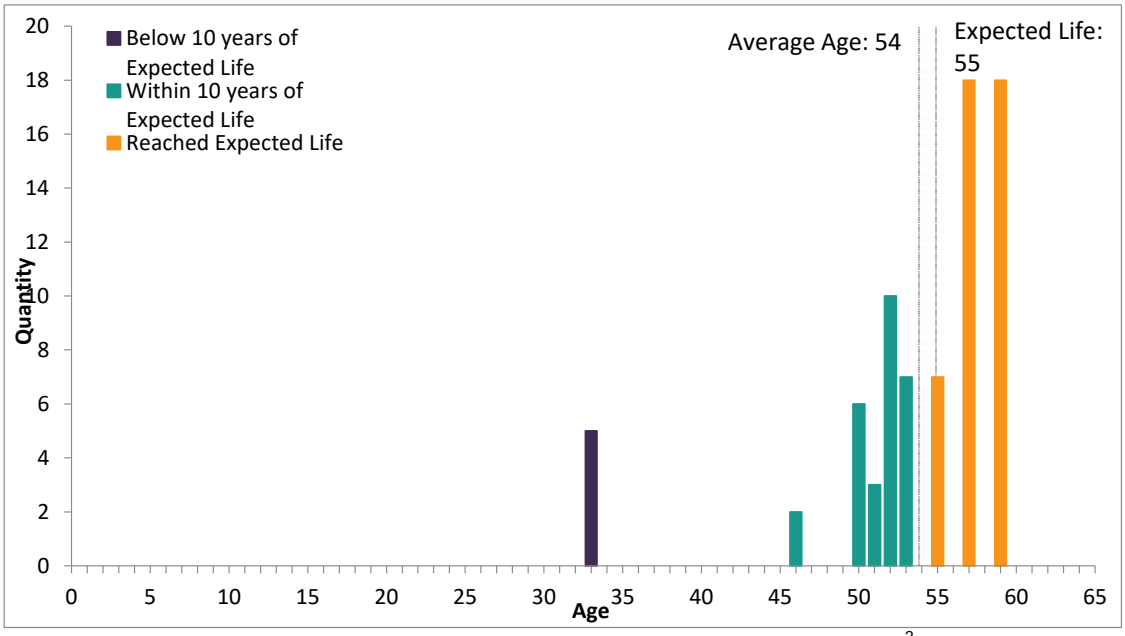


Figure 4: Hydro Ottawa's Station Oil Breakers Age Demographics[2]

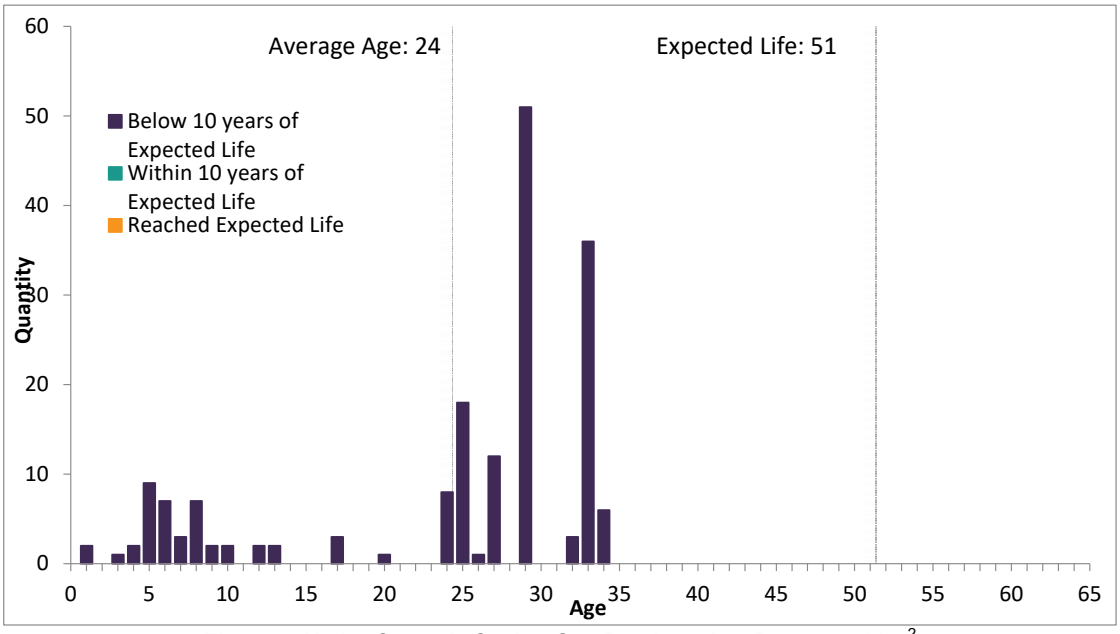


Figure 5: Hydro Ottawa's Station Gas Breakers Age Demographics[2]

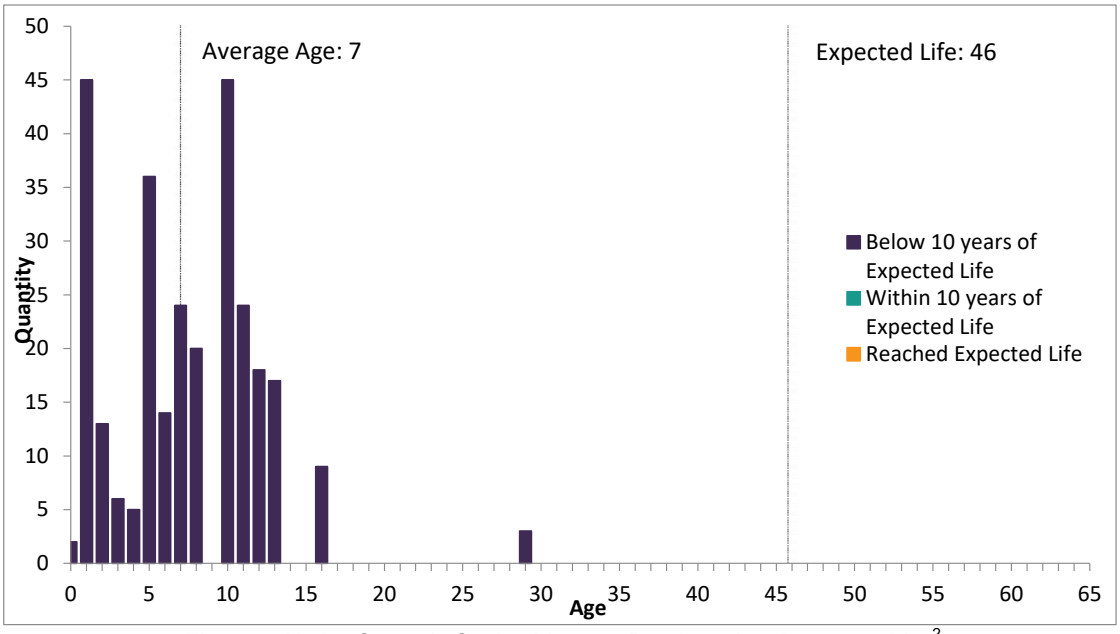


Figure 6: Hydro Ottawa's Station Vacuum Breakers Age Demographics[2]

4. Asset Management Objectives

Station switchgear and breakers require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact on service quality due to outages that originate at a specific breaker(s) as part of a mitigative or reactive electrical interruption
- Achieve less frequent electrical outages from external elements through the use of station switchgear enclosures
- Achieve shortened duration outages through the use of remote operable breakers connected to Hydro Ottawa's supervisory control and data acquisition system

Health, Safety & Environment Stewardship

- Achieve employee and public safety through the containment of electrical equipment within the switchgear enclosure
- Impact employee and public safety due to asset failure
- Impact environmental stewardship by releasing dielectric medium (oil or gas) through asset failure

Asset Value

- Increase in asset lifecycle cost as an emergency replacement is more costly than planned replacement[3]

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which may include several breakers or an entire switchgear lineup as well as other station equipment[3]
- Achieve increased operating productivity through the use of remote operable station breakers connected to Hydro Ottawa's supervisory control and data acquisition system

In order to monitor and strive to improve the performance of station switchgear and breakers, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 4 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 4: Station Switchgear and Breakers KPIs

KPI	*Target*
Station Switchgear/Breaker - SAIFI / 100 customers	0.11[4]
% of station breakers with health index information[5]	100%
% of station breakers with very poor health index score	0%

[3] Assumed based on resource and equipment requirements
[4] Based on a five (5) year average
[5] Asset health index KPI is based on timely data, that is, in line with the inspection cycle in GCS0015 - *Thermographic Scanning of Power Lines and Distribution Apparatus*

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections and testing on its station switchgear and breakers. The information from the inspections and testing are used to calculate station breaker's health index through the Asset Condition Assessment (ACA) described in section 6.2. The detailed inspections are completed varying prescribed frequencies based on inspection task and equipment characteristics detailed in SIP0003*Station Switchgear and Breaker Testing and Maintenance Procedure*. Hydro Ottawa has detailed inspection information on 38%[6] of its station breakers which results in health indexes shown in Figure 7 below using the ACA methodology.

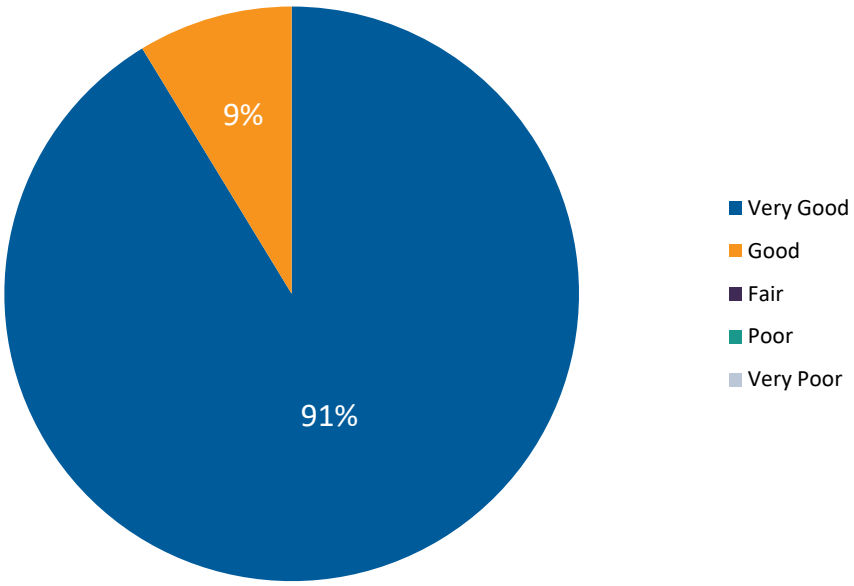


Figure 7: Hydro Ottawa Station Breaker Condition

Table 5: Station Breaker Condition KPIs

KPI	Target	2018
% of station breakers with a health index score	**100%**	38%
% of station breakers with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of station breakers with detailed inspections producing health index scores through ACAs. The station breaker inspection program was renewed in 2018 with an established inspection cycle compliant to the ACA process for all station breakers. Hydro Ottawa plans to have inspection information to determine a health index for all station breakers by 2020. Hydro Ottawa currently meets the target of having zero station breakers with a health index score of very poor.

Table 6: Station Breaker Inspection Plan

KPI	Target	2019	2020
% of station breakers with health index information	**100%**	75%	100%

[6] Information as of August 2019

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). HOL's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement to reduce the number of outages year-over-year.

Table 7: Station Switchgear & Breaker Reliability KPI

KPI	*Target*	*2014*	*2015*	*2016*	*2017*	*2018*
Station Switchgear/Breaker - SAIFI / 100 customers	**0.11**	0.18	0.0	0.36	0.0	0.0

Hydro Ottawa currently meets the reliability target for outages due to defective station switchgear and breakers and will continue to monitor reliability metrics for trends and improvements.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades station switchgear and breakers due to various drivers described in Table 8 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Station switchgear and breakers are installed as per approved procedures and standards available in the Stations and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and associated assets at the station(s) in question are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 8: Drivers for Station Switchgear and Breaker Installations / Replacement / Removals

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work driven by customer and third party requests. For station switchgear and breakers these may include:

Customer Connections

- Upgrade an existing station switchgear and/or breakers to support service equipment
- New station switchgear and/or breakers installed to support service equipment



Figure 8: Station Metal Enclosed Switchgear

Table 9 shows the historical station switchgear and breakers issued to the field for various activities under System Access.

Table 9: System Access – Station Breakers Installed / Replaced / Upgraded

Description	2014	2015	2016	2017	2018
Customer Connection	0	0	0	0	0

Hydro Ottawa has been approached by customers with significant electrical loads which may require station switchgear and breakers to be upgraded. Single party requests deemed to be above and beyond normal system load planning criteria that require an upgrade to station switchgear and/or breakers are classified as System Access. Station switchgear and breakers upgraded for capacity reasons resulting from general load growth are categorized under Syststem Service.

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of station switchgear and breakers. As described in Section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a station switchgear and breaker failure. Hydro Ottawa replaces station switchgear and breakers annually based on feedback from Hydro Ottawa staff, through visual inspections and the ACA health index results from inspections. Table 10 shows the historical station switchgear switchgear and breakers, based on manufacture date, issued to the field for various activities under System Renewal. Typically entire switchgear assesmblies are issued for Planned Renewal, wheras Corrective Renewal would depend on the requirement determined on a case by bcase basis.

Table 10: System Renewal – Station Breakers Replaced / Upgraded

Description	2014	2015	2016	2017	2018
Corrective Renewal	3	2	0	2	1
Planned Renewal	11	23	4	7	17
Assets Damaged by Third Parties	0	0	0	0	0

Corrective Renewal

Station switchgear and breakers which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual during monthly station inspections or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 11. Where applicable, the station switchgear and breakers may be upgraded to align with future plans such as upgrading the capacity.

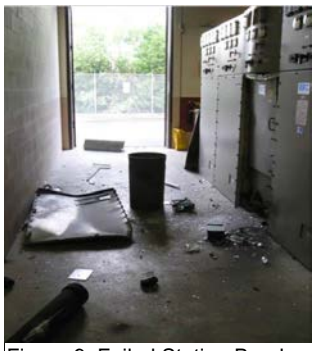


Figure 9: Failed Station Breaker

Table 11: Station Switchgear and Breaker Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	Critical Replacement (Imminent Risk)
Damaged beyond repair	Dielectric breakdown
Inoperable	Irreplaceable component
Extreme corona discharge	Loss of pressure (vacuum or SF6)
Time/travel tests above operable limits	Contact resistance test failed
Health index of 0%	Insufficient health index (very poor / < 30%)

Planned Renewal

Station switchgear and breakers which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk under the Planned Renewal program. Hydro Ottawa reviews station switchgear and breaker's calculated ACA health index and those in a poor state (health index score of >=30% and < 50%) are planned for replacement in Hydro Ottawa's station switchgear renewal program. Additionally, station switchgear and breakers may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained. Hydro Ottawa actively reviews other station assets and where additional poor condition assets exist a project to replace all assets under the station major rebuild program will be created.



Figure 10: Rusted Station Switchgear Enclosure

Assets Damaged by Third Parties
Station switchgear and breakers which are damaged due to third parties are replaced immediately after the area is made safe. Historically, this is rare for station assets due to the access restrictions and protective enclosures such as fencing or buildings.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by station switchgear and breaker work, but may require station switchgear and breakers to be installed, upgraded or replaced to accomplish the identified objectives. The primary driver which affects station switchgear and breakers is capacity improvements. Projects under this driver aim to improve Hydro Ottawa's system accessibility for load and energy resource facility customer by removing capacity constraints.

Station switchgear and breakers may be replaced before their end-of-life based on technical requirements or overall economic efficiencies to accommodate System Service projectsTable 12 shows the historical station breakers issued to the field under System Service.

Table 12: System Service – Station Breakers Installed / Replaced / Upgraded

Description	2014	2015	2016	2017	2018
Capacity	0	7	12	0	0

6.2. Operations & Maintenance Plan

Station Switchgear and Breaker Inspection and Testing
Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and a detailed inspection to capture ACA information on the station switchgear and breakers (note visual inspection information for switchgear cell components are captured as part of the station breaker ACA data collection where applicable). Hydro Ottawa's employees perform visual inspections on station switchgear and breakers on a monthly or bi-monthly basis, based on location (urban/rural) and type of station (indoor/outdoor and open/enclosed). Visual condition and deficiencies are reported as described in the working procedure SIP0001 *Station Inspection, Resolution, and Tracking Process* so it can be rectified.

Hydro Ottawa also completes detailed inspection and testing on station switchgear and breakers dependent on their type following the operating procedure SIP0003 *Station Switchgear and Breaker Testing and Maintenance Procedure*. This procedure also details the time frames for the various tests to be performed. The testing and inspections completed on station breakers include:

- Ground resistance
- Insulation resistance
- Timing tests
- Insulation quality

Specifically for breaker testing, the work procedure WSS0012 *Testing SF6, Oil, and Air Circuit Breakers* is followed.

This information is used to calculate the overall condition of station switchgear and breakers by calculating a health index using the ACA method described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the station switchgear and breaker's condition. Results from inspections are stored in Hydro Ottawa's station maintenance software. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Station Switchgear and Breaker Repair
Hydro Ottawa performs maintenance and repair to station switchgear and breakers when there are minor issues which do not classify the asset as reaching end-of-life (through the inspection process mentioned above).

Hydro Ottawa performs proactive maintenance on station switchgear and/or breakers through cleaning to ensure flashovers do not occur due to dust, dirt or other contaminants and torqueing (tightening) connections to ensure proper fitting and assembly between parts. Hydro Ottawa also completes reactive maintenance through corrective repairs to switchgear and breakers based on the results of inspection.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses station switchgear and breakers depending on their condition when they are removed from service. While re-using station equipment is rare, it is occasionally required to support a failed asset or if a good condition asset is no longer required and can be used to replace a worse condition asset. In the case of re-using station switchgear and breakers, detailed inspections are required to ensure the asset is in proper working order after transportation, following the inspection requirements detailed in section 6.2. Where a station switchgear and/or breaker is decommissioned, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. Dielectric mediums (oil or gas) are disposed of based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa does not maintain a stock of spare station switchgear or breakers. The potential need for these assets during emergencies can arise from the drivers described in Table 9. Hydro Ottawa's substations include multiple switchgear and breakers to ensure redundancy due to the criticality of this asset class. In addition to redundant switchgear and breakers, distribution connections, through the use of overhead and underground conductor and switches, are utilized during emergencies to ensure the electrical system continues to be available to customers if switchgear and/or breakers are out of service.

In the scenario that a station asset (e.g.switchgear, breaker, bus, etc.) are removed from service due to maintenance or failure for an extended amount of time, further contingency plans are developed by the System Operations and Asset Planning sections with input from various stakeholders. This can include significant system switching to transfer other supply sources and operating station equipment above normal operating limits, but below equipment damage thresholds.



Figure 11: Redundant Station Switchgear Lineup

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. It is uncommon that Hydro Ottawa replaces station switchgear and breakers due to drivers under System Access.

Costs associated with this work are generally borne by the requesting party, with the exception of system expansion, which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms (e.g. Public Service Works on Highways Act).

Table 13: Forecasted System Access – Station Switchgear and Breakers Installed / Replaced / Upgraded

Description	*2019**	*2020**	*2021**	*2022**	*2023**	*2024**	*2025**
Customer Connection	0	0	0	0	0	0	0

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by assets reaching end of life based on information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue the constant monitoring, health index updates, inspections and maintenance of station switchgear and breakers. Hydro Ottawa therefore forecasts the future demand of station breakers replaced due to corrective renewal to be in line with historical averages. Station switchgear and breakers are replaced due to assets damaged by third parties are forecasted based on historical averages.



Figure 12: Station Metalclad Switchgear Installed in 2018

Hydro Ottawa plans to proactively replace station assets which result in a poor condition (health index score of >=30% and < 50%) through detailed inspections. Where this score is due to a specific component(s), full station switchgear and breaker replacement will be compared to the specific component(s) requiring repaire or replacement for economic and technical justification. Additionally, due to the risk posed by the number of station breakers in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined the number of station breakers which require proactive replacement to mitigate the risk. This replacement strategy will prioritize station breakers based on their ACA results, as well as, levelize the future replacement of the growing and aging fleet of assets. Specifically, this replacement considers not only breakers, but switchgear lineup and cell(s) replacement, whereby all components are evaluated against present standards. The feasbiliity of upgrading all switchgear components is also evaluated. This levelization allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual station breakers to be replaced or upgraded are shown in Table 14.

Table 14: Forecasted System Renewal – Station Switchgear and Breakers Replaced / Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Planned Renewal	34	0	0	0	11	40	0
Assets Damaged by Third Parties	0	0	0	0	0	0	0

*Estimated Quantities

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require station switchgear and breakers to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by prioritized projects which require work to be completed on these assets. The forecasted annual demand for station breakers is shown in Table 15.



Figure 13: High Voltage Station Breaker

Table 15: Forecasted System Service – Station Switchgear and Breakers Replaced / Upgraded / Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
System Capacity	7	2	0	13	0	0	11

*Estimated Quantities

7.4. Additional Factors

Hydro Ottawa reviews external factors which may impact station switchgear and breakers and their ability to continue to deliver value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose significant threat to station switchgear and breakers. One of the main impacts affecting station equipment is rising temperatures. During the summer months where system electricity demand is already the highest compared to the rest of the year, increased heat and corresponding electrical responses, such as air conditioning, can put strain on system equipment. An increasing occurrence of high heat conditions, coupled with continued electrical demand growth can strain and limit supply capacity of station switchgear. This strain and limitations results from design limitations of sation switchgear buses and breakers, specifically those used to tie buses together.. While this scenario is not anticipated under normal operating conditions, issues may arise during contingency, or asset failure. Constant and timely system and asset monitoring and forecasting are required to ensure station switchgear and breakers continue to operate safely and provide value through delivering the asset management objectives.

Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to station switchgear, and there are no current climate specific adaptations for this asset. This assessment will be periodicly reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (ex. station switchgear renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. stations) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Station switchgear and breaker assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a discrete method, due to their quantity, price and limited number, over their expected financial useful life of 40 years. The difference between the expected operating life and the financial useful life is that certain drivers require station switchgear and breakers to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's station switchgear and breakers is approximately $61.7M[7] which represents 9.0% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy* (i.e. straight line depreciation); therefore, the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's station switchgear and breakers is approximately $8.1M[7].

[7] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of station switchgear and breakers in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with station switchgear and breakers.

Hydro Ottawa also addresses issues with its station switchgear and breaker assets through the stations standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to stations assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

Furthermore, Hydro Ottawa is in the process of levelizing station switchgear and breaker replacement as described in Section 7.2 to allow for more predictive forecasting of cost and labour requirements.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 - *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to station switchgear and breakers achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0005**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Distribution Poles, Fixtures & Primary Overhead Conductors

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-12	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



Asset Management Plan – Distribution Poles, Fixtures & Primary Overhead Conductors

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1. Introduction

Hydro Ottawa's distribution poles, fixtures and primary overhead conductor are used to support and deliver electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.
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The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes the current condition and performance in order to identify gaps for continuous improvement and establish remedial actions to close them as well. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management System Plan*
Hydro Ottawa - GDS0003 - *Overhead Design Guidelines*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - OIS0005 - *Overhead Line Inspection Method*
Hydro Ottawa - OIP0001 - *Estimating Remaining Strength in a Wooden Pole*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - GNG0001 - *Guidelines for Thermography*
Hydro Ottawa - E&O intranet website - *Overhead Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Overhead Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Overhead Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Overhead Qualifications*
Hydro Ottawa - E&O intranet website - *Overhead Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Overhead Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Overhead Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Ontario Energy Board - *Distribution System Code*
CSA - C22.3 No.1 - *Overhead Systems*
British Standards Institution - ISO55001

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's distribution poles, fixtures and primary overhead conductor assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of poles, fixtures and overhead conductor assets can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to poles or overhead conductor includes the respective components below which allow for the successful use of the asset.

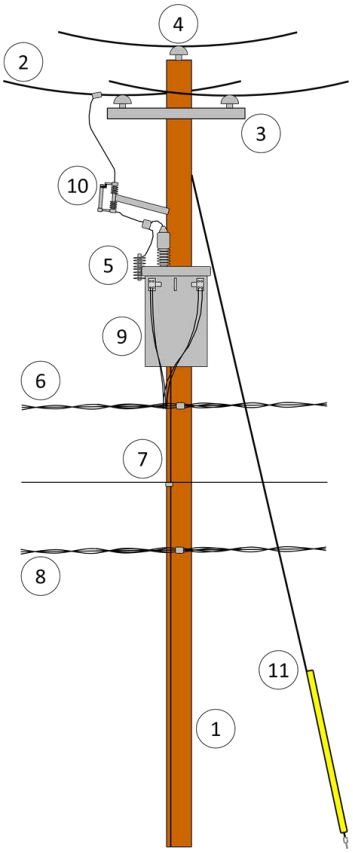


Figure 1: Distribution Poles, Fixtures and Overhead Conductor System (Illustrative Purposes Only)

Table 1: Distribution Poles, Fixtures and Overhead Conductor Functions

Figure Number	Component	Function
1	Poles	Poles support maintaining clearances for public and employee safety. They also support the transition of conductor between the overhead and underground electrical systems and equipment such as overhead switches, transformers, communication equipment and metering collectors.
2	Primary Overhead Conductor	Primary overhead conductor distributes electricity at medium voltages across the service territory. It also allows for a means of installing fault indicating equipment allowing for expedited fault finding and restoration.
3	Cross Arms	Cross arms support insulators and other electrical equipment such as overhead switches. They are also used as an anchoring point on dead-end poles.
4	Insulators	Insulators support overhead conductors while protecting equipment from the flow of current.
5	Surge Arrestors	Surge arresters protect the system and equipment by supressing voltage surges from various causes (e.g. lightning).
6	Secondary Overhead Conductors	Secondary overhead conductor distributes low voltage electricity suitable for customer use.
7	Grounding Conductor	Grounding conductor allows for a low impedance path for current to ground to limit buildup of unsafe voltage on the electricity system and equipment.
8	Third Party Equipment	Poles support third party equipment such as telecom wires, signs and third party low voltage services (e.g. street lighting).
9	Overhead Transformer	Pole mounted transformers are described in the Overhead Transformer AMP.
10	Fused Cut Out	Fused cut outs are described in the Overhead Switches AMP.
11	Guy Wires and Anchors	Guy-wires and anchors support unbalanced lateral loading and can be used to support the pole under inclement weather. A high visibility plastic cover is used for public and employee safety.

Table 2: Class, Sub-class and Components of Poles, Fixtures and Overhead Conductor

Class	*Sub-Class*	*Components*
Pole	Wood	Cross Arm, Arrestor, Guy-Wire/Guard, Anchor, Ground Wire, Ground Rod
	Composite	Cross Arm, Arrestor, Guy-Wire/Guard, Anchor, Ground Wire, Ground Rod
	Concrete	Guy-Wire/Guard, Anchor, Cross Arm, Arrestor, Ground Wire, Ground Rod
	Metal	Guy-Wire/Guard, Anchor, Cross Arm, Arrestor, Ground Wire, Ground Rod
Primary Overhead Conductor	Aluminum	Insulator
	Copper	Insulator

Poles are one of Hydro Ottawa's largest asset classes by asset count with Hydro Ottawa owning 48,506[2]. Hydro Ottawa also owns equipment operating on 14,119[2] poles that are owned and maintained by third parties. Hydro Ottawa does not actively manage third party owned poles. In addition to poles are the accompanied fixtures or components which include cross arms, arresters, guy wires and anchors.

While the majority of distribution poles are made of treated wood, non-wood poles are also utilized as shown in Figure 2 below. Currently, Hydro Ottawa has installation dates stored in the Geographic Information System (GIS) for approximately 32%[2] of its distribution poles. Where installation information is not available, the installation date has been estimated using manufacture dates of associated assets or known installation dates for poles within the region. The overall age demographics of poles in the distribution system are shown in Figure 3 below and show the average age of this asset class to be 35[2] years. The expected operating life of wood poles, where probability of failure is approximately 2% or greater, is an effective age of 53 years. There are 12,089[2] poles that have reached the expected service age and 6,128[2] within 10 years.

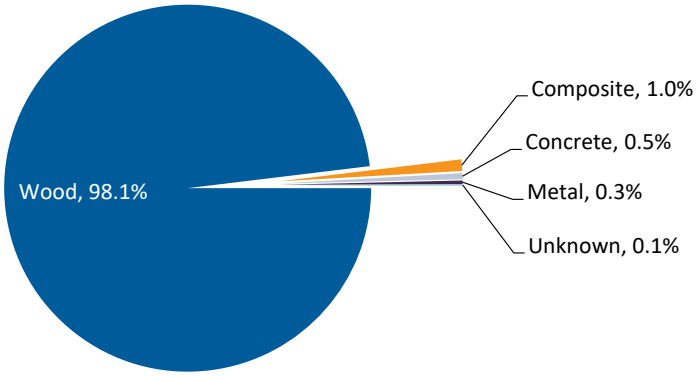


Figure 2: Hydro Ottawa's Pole Sub-Class[2]

[2] Information as of December 2018

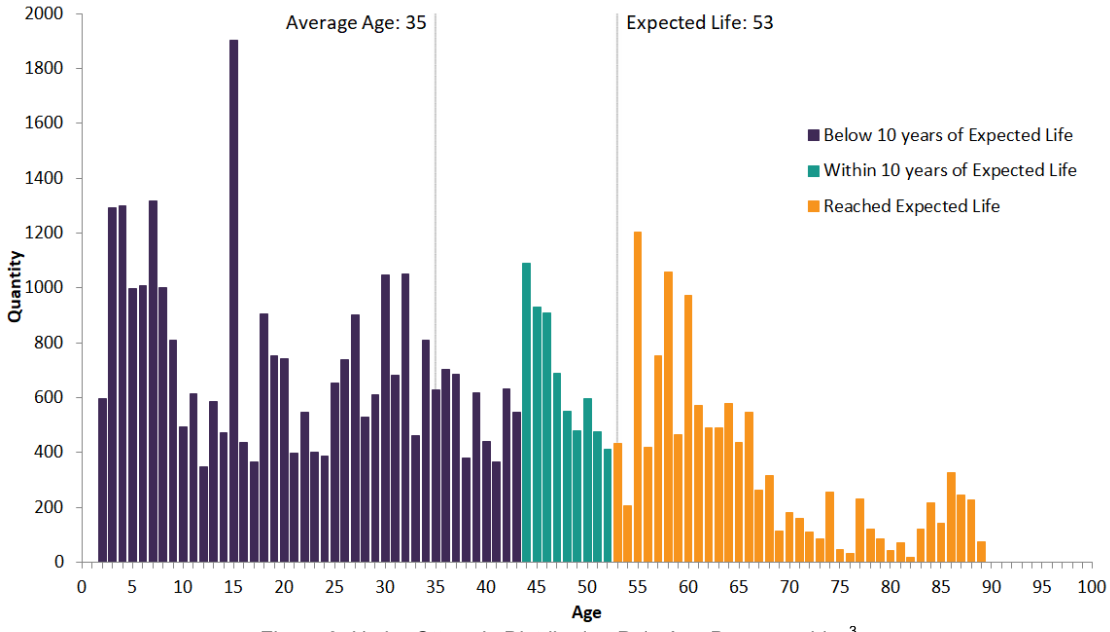


Figure 3: Hydro Ottawa's Distribution Pole Age Demographics[3]

Supported by Hydro Ottawa's distribution poles and fixtures are insulators and 2,745km[3] of overhead conductor. The vast majority of overhead conductor is bare conductor, either aluminum or copper, using the surrounding air as insulation. Hydro Ottawa's system has various bare conductor material types which are shown in Figure 4.

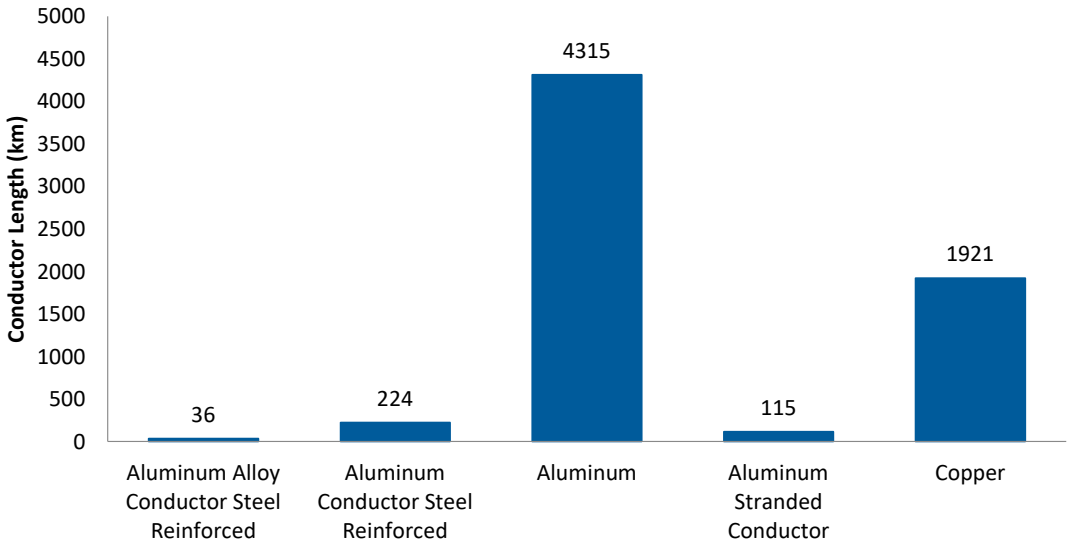


Figure 4: Hydro Ottawa's Primary Overhead Bare Conductor Sub-Class[3]

[3] Information as of December 2018

4. Asset Management Objectives

Distribution poles, fixtures and overhead conductor require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact on system reliability through electrical interruptions which may be localized, affecting customers connected to that specific pole or overhead conductor, or a wider outage, affecting a large number of customers supplied by the connecting conductors
- Achieve quicker reliability restoration as failed poles, fixtures or overhead conductors are easier to locate compared to underground equipment

Health, Safety & Environmental Stewardship

- Impact employee and public safety due to fallen poles and downed overhead conductors
- Achieve clearances for public safety from roads, walk ways, rail lines, buildings, etc.
- Impact environmental stewardship by failing to support oil filled equipment

Asset Value

- Achieve reduced costs due to economic effectiveness of overhead vs. underground distribution
- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[4]

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually has multiple poles in a row[4]

In order to monitor and strive to improve the performance of distribution poles, fixtures and overhead conductors, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Pole, Fixture and Overhead Conductor KPIs

KPI	*Target*	*KPI*	*Target*
Pole - SAIFI / 100 customers	0.5[5]	% of poles with health index information[6]	100%
Overhead conductor - SAIFI / 100 customers	3.55	% of poles with very poor health index score	0%
Arrester - SAIFI / 100 customers	1.25		
Insulator - SAIFI / 100 customers	2.45		
SAIFI due to tree contacts	8.35		

[4] Assumed based on resource and equipment requirements and economies of scale
[5] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both periodic visual and detailed inspections on wood poles. The information from the detailed inspections is used to calculate a wood pole's health index through the Asset Condition Assessment (ACA) described in section 6.2. This includes assessing the condition of the pole's shell, top, attached fixtures and a non-destructive drill test to determine the pole's remaining strength. The detailed inspections are completed on a 10 year cycle where areas with older poles or known issues are prioritized. Hydro Ottawa has detailed inspection information on 82%[7] of its distribution poles which results in health indexes shown in Figure 5 below using the ACA methodology. The remaining inspection data will be obtained as part of the maintenance activities described in Section 6.2.

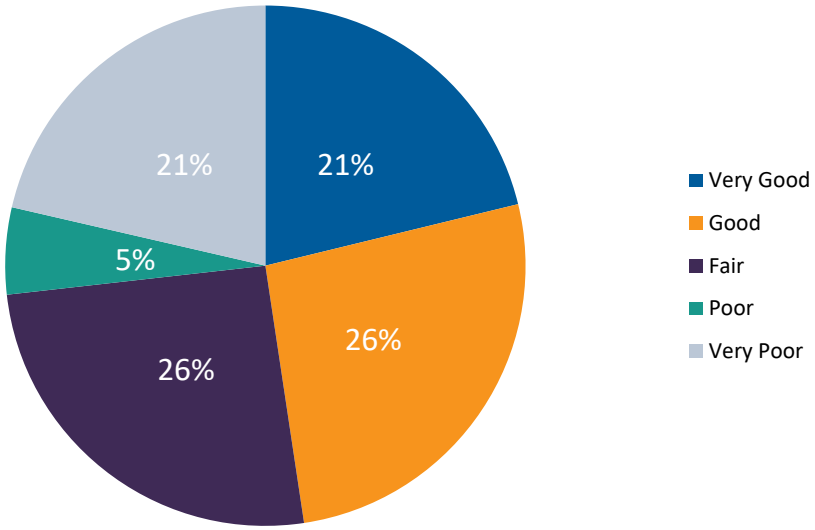


Figure 5: Count of Hydro Ottawa Wood Pole Population by Condition[7]

Hydro Ottawa's poles which have reached their end-of-life require corrective renewal and are categorized as either an emergency, requiring immediate replacement, or critical, replacement scheduled in the short-term, as described in section 7.2.

Hydro Ottawa's pole fixtures and overhead conductors are assessed through visual inspections. However, health index scores through ACA are not determined. Should concerns be identified through these inspections the issue is remediated, however, the majority of fixtures and overhead conductor are replaced alongside work on poles or pole supported equipment as described in section 6.

Table 4: Distribution Pole Condition KPIs

KPI	Target	2018
% of poles with a health index score	**100%**	82%
% of poles with ACA compliant inspections with a very poor health index score	**0%**	20%



Figure 6: Pole with Degraded Shell

[7] Information as of August 2019

Hydro Ottawa currently does not meet the target of poles with detailed inspection producing health index scores through ACAs shown in Table 4. Hydro Ottawa's detailed inspection plan has been developed to a health index for all poles by 2020 as shown in Table 5.

Table 5: Pole Inspection Plan

KPI	Target	2019	2020
% of poles with health index information	**100%**	91%	100%

Hydro Ottawa currently does not meet the target on poles with ACA compliant inspections with a very poor health index score in the distribution system. While Hydro Ottawa replaces these poles through emergency and critical replacements outlined in section 6.1.2, it is expected that poles will continue to be identified with very poor condition scores through the detailed inspection program. While Hydro Ottawa strives to keep the number of very poor poles low through planned replacements as described in Section 6.1.2, it is expected that the target will not be achieved until two years after all poles have detailed inspections to allow time to prioritize the replacements once identified.

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI X 100). In addition, the contribution of tree impacts is recorded to identify the effectiveness of Hydro Ottawa's tree trimming program. Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Table 6: Distribution Pole and Overhead Conductor Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Pole - SAIFI / 100 customers	**0.28**	0.0	0.51	0.01	0.48	0.38
Overhead conductor - SAIFI / 100 customers	**2.21**	3.67	0.59	0.64	5.92	0.21
Arrester - SAIFI / 100 customers	**1.80**	1.82	0.46	0.51	2.13	4.05
Insulator - SAIFI / 100 customers	**1.64**	3.07	2.68	1.22	1.01	0.18
Tree Contact Outages - SAIFI / 100 customers	**9.21**	4.70	5.02	7.93	12.03	16.38

Hydro Ottawa does not currently meets the reliability target for outages due to defective distribution poles, arresters and outages due to tree contacts, however was above the target for overhead conductors, and insulators.

Arresters – 2018 had a higher than usual amount of customers affected due to failed arresters. In 2018 one outage accounted for 39% of the SAIFI impact due to as failed arrester. Hydro Ottawa will continue to monitor defective arresters impact on reliability.

Outages due to Tree Contacts are on an increasing trend over the last 5 years as seen in Table 6. The increasing trend is attributed largely to an increase in large tree limbs, and full trees falling into wires from outside the powerline corridor, typically as a result of extreme weather events. Hydro Ottawa has reviewed and continues to evaluate the performance of its vegetation management program and is increasingly working with customers to address risk trees outside the trim zones wherever possible.

Hydro Ottawa experienced three major storms in 2018. The first occurred on April 16th and involved freezing rain and high winds. The second occurred on May 5th and involved high winds. The third occurred on September 21st and involved a tornado and high winds throughout the service territory. During the three events the weather, combined with pole condition, caused significant damage to poles, fixtures and overhead conductor and impacted Hydro Ottawa's asset management objectives, specifically Hydro Ottawa's levels of service. Detailed analyses and recommendations were compiled for the first two storms in the respective System Activity Investigation Reports SYS-18-003 and SYS-18-004.



Figure 7: Outage Caused by Fallen Tree on Overhead Conductor

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades distribution poles, fixtures and overhead conductors due to various drivers described in Table 7 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Poles, fixtures and overhead conductors are installed as per GDS0003 *Overhead Design Guidelines* and the approved procedures and standards available in the Overhead and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While generally there is a single driver initiating a project, the affected assets and surrounding area are reviewed to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 7: Drivers for Distribution Pole, Fixtures and Overhead Conductor Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations (e.g. City road widenings)
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Asset damaged by third parties (e.g. vehicle accident)
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. These include:

Customer Connections

- Upgrade an existing pole and fixtures to support service equipment
- New poles, fixtures and overhead conductor installed to support service equipment
- New poles, fixtures and overhead conductor installed to expand Hydro Ottawa's system

Relocated Assets

- Relocate poles, fixtures and overhead conductor to accommodate work and eliminate clearance concerns

Table 8 shows the historical poles and overhead conductor issued to the field for various activities under System Access.

Table 8: System Access – Poles and Overhead Conductor Installed / Replaced / Upgraded

Description	*Asset*	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	Pole	87	157	178	122	160
	Overhead Conductor (km)	37.9	48.1	24.9	20.4	39.2
Assets Relocated	Pole	84	76	104	51	68
	Overhead Conductor (km)	5.9	2.1	21.0	7.0	10.7

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the distribution poles, fixtures and overhead conductor. As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a pole, fixture or overhead conductor failure. Hydro Ottawa replaces poles each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff through visual inspections, the ACA health index results from detailed inspections and feedback from third parties citing concerns. Fixtures and overhead conductors are replaced if an issue is identified through inspections detailed in section 6.2 or in conjunction with poles. Table 9 shows the historical poles and overhead conductor issued to the field for various activities under System Renewal.

Table 9: System Renewal - Poles and Overhead Conductor Replaced / Upgraded

Description	Asset	2014	2015	2016	2017	2018
Corrective Renewal	Pole	80	72	141	122	253
	Overhead Conductor (km)	1.4	0.5	4.8	2.7	15.4
Planned Renewal	Pole	228	522	498	506	355
	Overhead Conductor (km)	10.4	16.3	58.0	54.9	15.2
Assets Damaged by Third Parties	Pole	29	22	31	23	32
	Overhead Conductor (km)	0.1	0.3	0.1	0.1	0.1

Corrective Renewal

Poles, fixtures and overhead conductor which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 10. Where applicable, the pole may be upgraded to align with future plans or the material changed per GDS0003 *Overhead Design Guidelines* to ensure the asset's full lifecycle is achieved such as replacing a woodpecker damaged wood pole with a composite pole.



Figure 8: Pole Woodpecker Damage

Table 10: Distribution Poles, Fixtures and Overhead Conductor Corrective Renewal Criteria

Emergency Renewal (Immediate Risk)	Critical Renewal (Imminent Risk)
Pole on the ground	Rotten butt
Detached pole (non-securable)	Detached pole (engineered securable)
Detached or Broken cross arm	Excessive lean (> 15 degrees)
Health index of 0%	Insufficient health index (very poor / < 30%) including damage from woodpeckers
Corroded conductor	Cracked insulator



Figure 9: Leaning Pole

Planned Renewal

Poles, fixtures and overhead conductor which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews distribution pole's calculated ACA health index and poles in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's pole renewal program. Poles replaced under this program are generally grouped along a specific pole line or area to take advantage of efficiencies gained when replacing numerous poles within similar proximity at the same time. Hydro Ottawa does not calculate a

health index for fixtures or overhead conductors, but rather replaces these assets along with pole replacement projects if the asset does not meet Hydro Ottawa standards, as well as, if integrity issues have been identified. This includes overhead conductor such as #4 aluminum conductor steel-reinforced and #6 copper conductors[8] and problematic insulators including "wart" porcelain, porcelain pin (Canadian porcelain), horizontal installed porcelain pin and Ohio brass porcelain on standoff bracket. Additionally, fixtures and overhead conductor may be replaced or upgraded in conjunction with planned pole renewal if capacity in an area is expected to change.

Assets Damaged by Third Parties
Poles, fixtures and overhead conductor which are damaged due to third parties are replaced immediately after the area is made safe. Historically this damage has been due to motor vehicle accidents or construction equipment. In such instances, cost of replacement are recovered from the third party or their insurance provider.

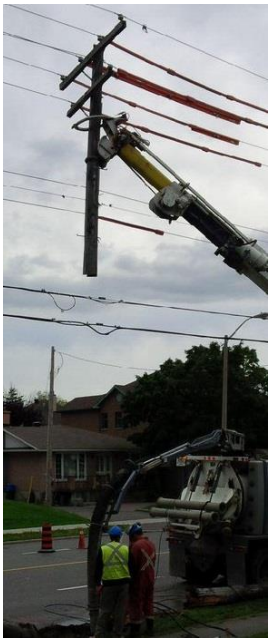


Figure 10: Detached Pole due to Motor Vehicle Accident

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by pole, fixture or overhead conductor work, but may require poles, fixtures and/or overhead conductor to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects include:

Voltage Conversion
- Reduce Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements
- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades
- Improve Hydro Ottawa's System Accessibility for load and energy resource facility customers by removing capacity constraints e.g. upgrading poles to allow for more overhead conductors, installing new overhead conductor or upgrading existing overhead conductor

Poles, fixtures and overhead conductor are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they require being replaced, upgraded or installed. Additionally, the condition of the pole is reviewed to determine if replacement due to end-of-life is anticipated. Poles, fixtures and overhead conductor may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 11 shows the historical poles and overhead conductor issued to the field for various activities under System Service.

Table 11: System Service – Poles and Overhead Conductor Replaced / Upgraded / Installed

Description	Asset	2014	2015	2016	2017	2018
Voltage Conversion	Pole	432	290	65	65	0
	Overhead Conductor (km)	19.3	44.3	21.1	18.2	9.2
System Reliability	Pole	10	81	114	118	106
	Overhead Conductor (km)	5.4	18.9	46.0	65.5	23.1

[8] Hydro Ottawa Safety, Environment and Business Continuity Notice 08-13

Description	Asset	2014	2015	2016	2017	2018
System Capacity	Pole	107	63	4	2	14
	Overhead Conductor (km)	34.1	15.2	1.6	0.0	26.6

6.2. Operations & Maintenance Plan

Pole Third Party Attachments
Hydro Ottawa allows the attachment of various third party owned equipment to distribution poles such as telecommunication wires, street light conductor and signage. These attachments must comply with the applicable technical safety requirements and the third party must have an attachment agreement with Hydro Ottawa. Hydro Ottawa performs numerous work functions to effectively manage the various attachments to poles. This includes:

- pole attachment program and permit administration
- pole attachment auditing and field verifications
- administration and field verifications of pole attachment transfers
- pole butt removal when delayed due to pole attachment transfers

Additionally, Hydro Ottawa is often the first point of contact by the public or emergency services when a tree is resting on third party attachments or if the attachment is hanging low or on the ground. Hydro Ottawa responds to these calls to make the area safe if required before notifying the appropriate owner.

Vegetation Management
Hydro Ottawa manages the vegetation that encroaches on or around the overhead conductors through the use of external vegetation contractors. The Hydro Ottawa service area is currently divided into regions for vegetation management: 12 suburban areas which are trimmed on a 3 year cycle and 16 core areas which are trimmed on a 2 year cycle. Vegetation management is completed in specified areas, beyond those identified in the cycle year, due to quick growing tree species. Additional vegetation trimming is completed throughout the city in response to customer driven concerns and escalations from dead or dying trees and broken limbs from inclement weather. Hydro Ottawa utilizes internal operation resources to isolate overhead conductors to allow for contractors to complete work safely. These activities aim to ensure public and employee safety and improve system reliability, especially for tree related outages during storms or adverse weather events.


Figure 11: Pole Vegetation Overgrowth

Poles, Fixtures and Overhead Conductor Inspection and Testing
Hydro Ottawa proactively performs both a visual inspection to report deficiencies found for poles, fixtures and overhead conductor and a detailed inspection to capture ACA information on the distribution wood poles. Hydro Ottawa's employees perform visual inspections on distribution poles, fixtures and overhead conductor regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are communicated per the working procedure OIS0001 *Overhead Distribution System Inspection* so the issue can be rectified. Hydro Ottawa also uses external contractors to perform infrared scanning following GNG0001 *Guidelines for Thermography*. Issues found from this inspection are reported to Hydro Ottawa and actioned for remedy. Typically, with respect to overhead conductor, issues are not found on overhead conductors themselves, but rather their connections.

Hydro Ottawa uses external contractors to perform a detailed inspection on wood poles following the working procedure OIS0005 *Overhead Line Inspection Method*. This includes a non-destructive drill test to determine the remaining strength of poles performed below grade and on the lower section of a pole following OIP0001 *Estimating Remaining Strength in a Wooden Pole*. The remaining strength is used to

assess the pole's ability to perform its designed function. Hydro Ottawa also determines the overall condition of poles by calculating a health index using the ACA described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the pole including wood pecker and shell damage, cross arm condition and pole top condition. Hydro Ottawa undertakes visual inspections to track condition of non-wood poles. Best practices in asset inspection and testing methods for these non-wood poles continues to be reviewed.

Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. Inspections are prioritized based on areas where information is unknown or areas with old poles, areas with recurring issues and where information is required to determine project alternatives. The information provided through inspections is used to determine the asset maintenance and renewal plan.

Pole and Fixture Repair
Hydro Ottawa reactively performs maintenance to repair distribution poles and fixtures when there are minor issues which don't classify the pole as reaching its end-of-life (through the inspection process mentioned above). These activities are aimed to sustain the performance of poles and fixtures, mitigate further deterioration and to achieve the asset's full service life. The activities include:

- patching small woodpecker holes (wood poles only) to deter (doesn't improve condition) further damage which would increase the hole's size leading to reduced pole strength
- install woodpecker wrap (wood poles only) to deter (doesn't improve condition) further damage
- repairing guy wires and anchors which are used to support unbalanced forces due to the attached overhead equipment and guy guards used to increase the visibility of the guy wire to the public
- repairing or replacing fixtures as necessary (e.g. cross arm)
- straightening leaning poles
- installing metal guards around the bottom of the pole to deflect damage caused by snow plows, or other like equipment



Figure 12: Pole Patched Woodpecker Holes

Overhead Conductor Repair
Hydro Ottawa reactively performs maintenance to repair overhead conductor when there are minor issues which don't classify the overhead conductor as reaching its end-of-life (through the inspection process mentioned above). These activities are aimed to sustain the performance of overhead conductor, mitigate further deterioration and to achieve their full service life. The activities include:

- repairing cut, missing or damaged ground conductors
- repairing or replacing overhead connectors
- repairing overhead conductor after the use of temporary devices, e.g. replacement of automatic overhead line splices ("quick sleeves"[9])

[9] Hydro Ottawa overhead standard's committee bulletin OHCB-02-12

Insulator Wash

Hydro Ottawa proactively uses external contractors to complete washing of porcelain overhead insulators in high traffic or contamination areas. Washing is used to clean contamination build-up from insulators which would otherwise cause a decrease in the insulation strength and result in tracking and flashover from electrical arcing. Arcing can cause electrical losses, pole fires and outages to the system thereby negatively impact asset management objectives Hydro Ottawa prioritizes porcelain insulators washes by factors including voltage class, location/environment and areas which have experienced historical issues.



Figure 13: Overhead Insulator Washing – K-Line Power Services

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses distribution poles depending on their condition when they are removed from service. Hydro Ottawa strives to re-use poles following the provisions in GDS0003 *Overhead Design Guidelines* which includes factors such as pole condition, age, treatment type and species of wood. In some instances, a pole may need to be cut prior to removal due to telecom attachments, making re-use impossible. Fixtures and overhead conductors are re-used where possible, when they are undamaged during decommissioning. This material is disposed of through metal recycling where Hydro Ottawa recovers scrap value.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of poles, fixtures and overhead conductor which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 10. This stock allows Hydro Ottawa to replace such poles, fixtures and overhead conductor in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of over 100 wood and composite poles of various heights and classes and approximately 15km of overhead conductor of various sizes and material to be used during emergencies. Additionally, Hydro Ottawa stocks numerous quantities of various types of pole fixtures including cross arms, insulators and arresters. The minimum quantity of poles and overhead conductor is based on the asset's usage and the need to have replacement assets should an emergency occur.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of poles, fixtures and overhead conductors should an issue arise or more assets be required. Additionally, this includes using contractors beyond normal scopes of work to assist Hydro Ottawa crews in asset installation during emergencies.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual poles and overhead conductor to be installed, replaced or upgraded are shown in Table 12.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms e.g. Public Service Works on Highways Act.

Table 12: Forecasted System Access – Poles and Overhead Conductor Installed / Replaced / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	Pole	141	141	141	141	141	141	141
	Overhead Conductor (km)	34.1	34.1	34.1	34.1	34.1	34.1	34.1
Assets Relocated	Pole	77	77	77	77	77	77	77
	Overhead Conductor (km)	9.3	9.3	9.3	9.3	9.3	9.3	9.3

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by assets reaching end of life based on information provided through inspections as described in sections 6.1.2 and 6.2. The renewed detailed inspection program for poles in 2016 identified a significant amount of poles with health index scores of very poor which were replaced in 2016 and 2017 under corrective renewal. Hydro Ottawa plans to continue with this level of pole inspections and therefore forecasts the future demand of poles replaced due to corrective renewal to be in line with that seen in 2016 and 2017. Hydro Ottawa expects that this trend should reduce once every pole has received a detailed inspection. Poles replaced due to assets damaged by third parties are forecasted based on historical averages.



Figure 14: Overhead Asset Replacement

Hydro Ottawa plans to proactively replace poles which result in a poor condition (health index score of < 50%) through detailed inspections. Additionally, due to the risk posed by the number of poles in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined the number of poles which require proactive replacement to mitigate the risk. This replacement strategy will prioritize poles based on their ACA results, as well as levelize the future replacement of the growing and aging fleet of assets. This levelization allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. As fixtures and overhead conductor is replaced in conjunction with poles, historical averages and future plans are reviewed for forecasting future replacement. The expected annual poles and overhead conductor to be replaced are shown in Table 13.

Table 13: Forecasted System Renewal - Poles and Overhead Conductor Replaced / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal	Pole	150	150	150	150	150	150	150
	Overhead Conductor (km)**	6	6	6	6	6	6	6
Planned Renewal	Pole	354	362	400	400	400	400	400
	Overhead Conductor (km)	34.5	33.0	29.0	29.0	29.0	29.0	29.0
Assets Damaged by Third Parties	Pole**	27	27	27	27	27	27	27
	Overhead Conductor (km)**	0.2	0.2	0.2	0.2	0.2	0.2	0.2

*Estimated Quantities
**Based on 5 year historical data ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require distribution poles, fixtures and overhead conductor to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for poles and overhead conductor is shown in Table 14.

Table 14: Forecasted System Service – Poles and Overhead Conductor Replaced / Upgraded / Installed

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	Pole	34	28	0	48	120	29	0
	Overhead Conductor (km)	8.3	7.8	0.0	3.6	2.3	3.5	0.0
System Reliability	Pole	65	0	0	41	20	5	7
	Overhead Conductor (km)	4.0	0.2	0.0	6.5	0.8	0.7	1.3
System Capacity	Pole	95	113	180	37	143	0	0
	Overhead Conductor (km)	15.6	15.3	32.9	13.9	16.9	0.0	0.0

*Estimated Quantities

7.4. Additional Factors

Hydro Ottawa reviews external factors which may impact distribution poles, fixtures and overhead conductor and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to distribution poles, fixtures and overhead conductor as freezing rain, ice storms and high wind events have the capacity to exceed the asset's design limits. These events can lead to damaged assets and a negative impact to Hydro Ottawa's levels of service. Hydro Ottawa is undergoing a review of industry experts to provide a climate change study for the service territory and equipment standards.



Figure 15: Broken Poles during 2018 Ice Storm

Hydro Ottawa's distribution system climate vulnerability risk assessment identified existing risks, related to Pole assets for High-wind events, and increasing risks associated with increasing frequency of ice events in the coming years. Hydro Ottawa will be developing an adaptation plan, to incorporate increased resiliency to these events in the renewal of overhead infrastructure.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. pole renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. overhead) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Pole and overhead conductor assets along with their fixtures and components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 45 years. The difference between the expected operating life and the financial useful life is that certain drivers require poles, fixtures and overhead conductors to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's distribution poles is approximately $104.5M[10] which represents 15.3% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). The existing net book value of Hydro Ottawa's overhead conductor is $90.7M[10] which represents 13.3% of Hydro Ottawa's distribution assets within the scope of the AMS. Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy*, e.g. straight line depreciation. Therefore the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's distribution poles is approximately $10.1M[10] and overhead conductor is $8.1M[10].

[10] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of distribution poles, fixtures and overhead conductor in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with distribution poles, fixtures and overhead conductor.

Hydro Ottawa also addresses issues with distribution poles, fixtures and overhead conductor assets through the overhead standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards with relevant to overhead assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

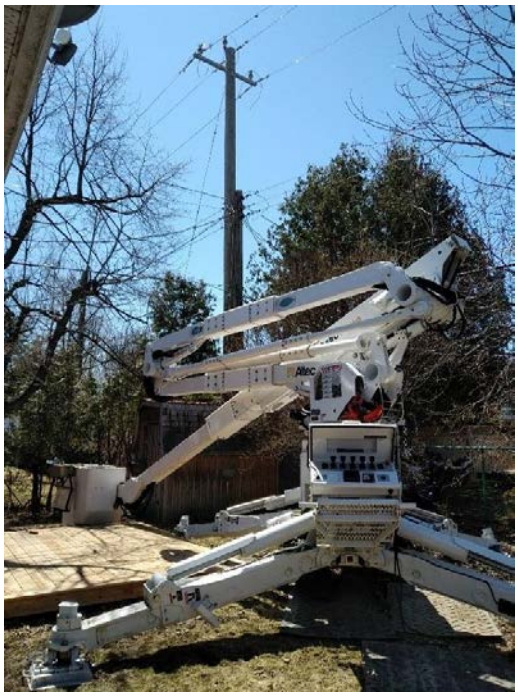


Figure 16: Portable Backyard Articulating Telescopic Aerial Device

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the IAP-0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution poles achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan (DSP)*, within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0006**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Distribution Overhead Switches

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-21	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



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1. Introduction

Hydro Ottawa's distribution overhead switch assets are used to support and deliver electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management Plan*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - OIS0003 - *Overhead Switch Inspection & Maintenance*
Hydro Ottawa - OIS0005 - *Overhead Line Inspection Method*
Hydro Ottawa - GCS0015 - *Thermographic Scanning of Power Lines and Distribution Apparatus*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - E&O intranet website - *Overhead Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Overhead Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Overhead Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Overhead Qualifications*
Hydro Ottawa - E&O intranet website - *Overhead Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Overhead Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Overhead Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's distribution overhead switch assets which include:

- load break switches;
- non-load break switches; and
- reclosers.

The system example of overhead switches can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to overhead switches includes the components below which allow for the successful use of the asset. In general, the purpose of an overhead switch is to isolate faulted sections of Hydro Ottawa's distribution system; minimize the impact to customers; isolate sections of Hydro Ottawa's distribution system to enable work to proceed while affecting the smallest part of the distribution system possible; isolate customers through requests; and provides backup supply from other feeder(s).

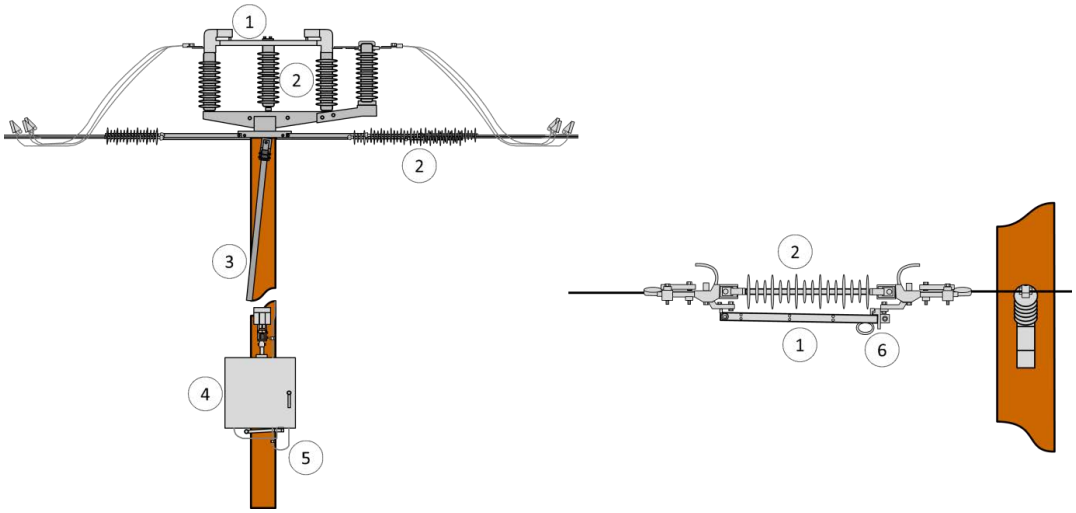


Figure 1: Overhead Switch (Illustrative Purposes Only)

Motor controls which drive motorized switch and mid-span openers (MSOs) are not included in the scope of this AMP.

Table 1: Overhead Switch Functions

Figure Number	Component	Function
1	Solid Blade	The solid blade of an overhead switch allows the flow of current when closed and interrupts the flow of current when opened.
2	Insulator	Insulators support overhead conductors while protecting equipment from the flow of current.
3	Operating Pipe	Operating pipe is the mechanism that engages the solid blade to open or close allowing for switching from the ground versus the top of the pole.
4	Control Cabinet	Control cabinets house the low voltage equipment necessary to communicate with, monitor, and control motor operated switches.
5	Control Wire	Control wire connects the control cabinet to the overhead switch's motor.
6	Hot Stick Operating Hook	The hot stick operating hook is a mechanical access point to manually open an overhead switch using a hot stick tool.
Not Shown	Communication Device	A communication device is an antenna or modem that provides remote operability to an overhead switch through the use of the control box and overhead switch's motor.

Figure Number	Component	Function
Not Shown	Fused Cutout	Fused cut-outs allow the flow of current when the current flowing through the fuse is less than the rated value of the fuse. The fuse melts and breaks when the current flowing through the fuse exceeds the rated value.

Table 2: Class, Sub-class and Components of Overhead Switches

Class	*Sub-Class*	*Components*
Overhead Switch	Load Break	Solid blade, Insulator, Operating Pipe, Control Wire, Hot Stick Operating Hook, Control Cabinet, Switching Mechanism, Interrupter, Fuse (optional)
	Non-Load Break	Solid blade, Insulator, Operating Pipe, Control Wire, Hot Stick Operating Hook, Control Cabinet, Switching Mechanism, Motor (optional)
Recloser	Recloser	Enclosure, Solid blade, Insulator, Operating Pipe, Control Wire, Hot Stick Operating Hook, Control Cabinet, Switching Mechanism, Interrupter

Hydro Ottawa owns 34,991[2] sets (set refers to one or more switches operating in concert, but not necessarily mechanically connected) of distribution overhead switches throughout the service territory. The majority of these switches are in-line fuses and fused cut-outs with a population of 26,758 the breakdown of the remaining types of overhead switches is shown in Figure 2, whereby gang operated refers to a single control operating multiple phases, and non-gang operated refers to a single control operating a single phase. All Hydro Ottawa overhead switches are inspected on a 3-year cycle, and identified deficiencies corrected.

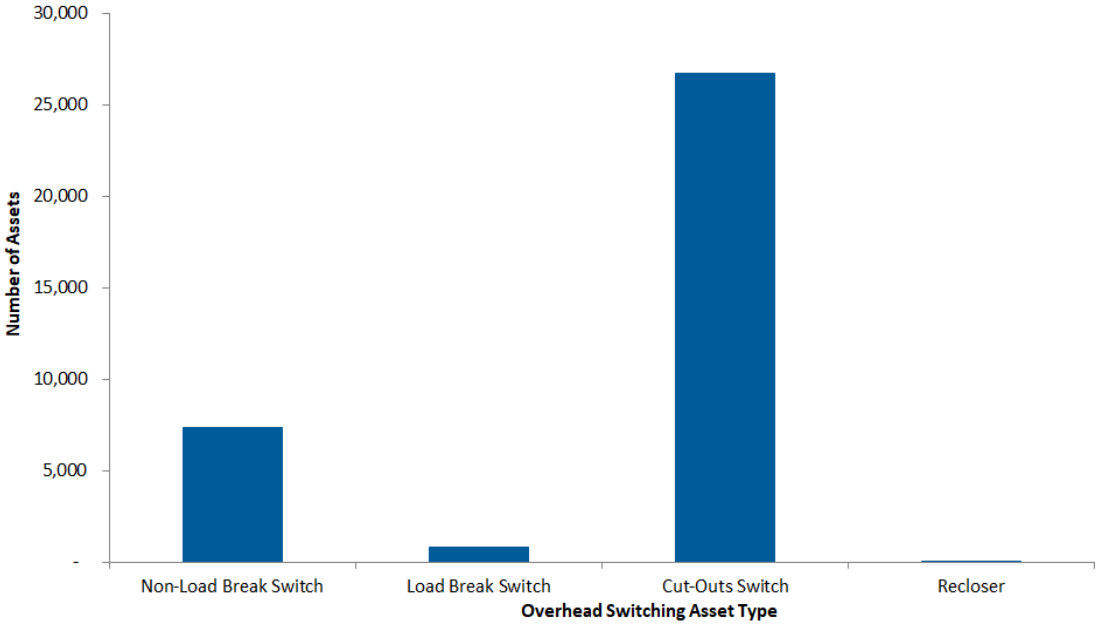


Figure 2: Count of sets of Hydro Ottawa's Distribution Overhead Switches by Sub-Class[2]

Most overheard switches, including in-line fuses and fused cut-outs are subject to a proactive inspection program but are not subject to proactive maintenance. 222 higher complexity switches and those switches whose failure carries a greater impact receive proactive maintenance and inspection programs have an overall age demographics shown in Figure 3 below. The expected operating life of overhead

[2] Information as of March 2019 and includes both single switches and sets (multiple group of switches)

switches with a proactive inspection and maintenance procedure, where the probability of failure is approximately 2% or greater, is 25 years.

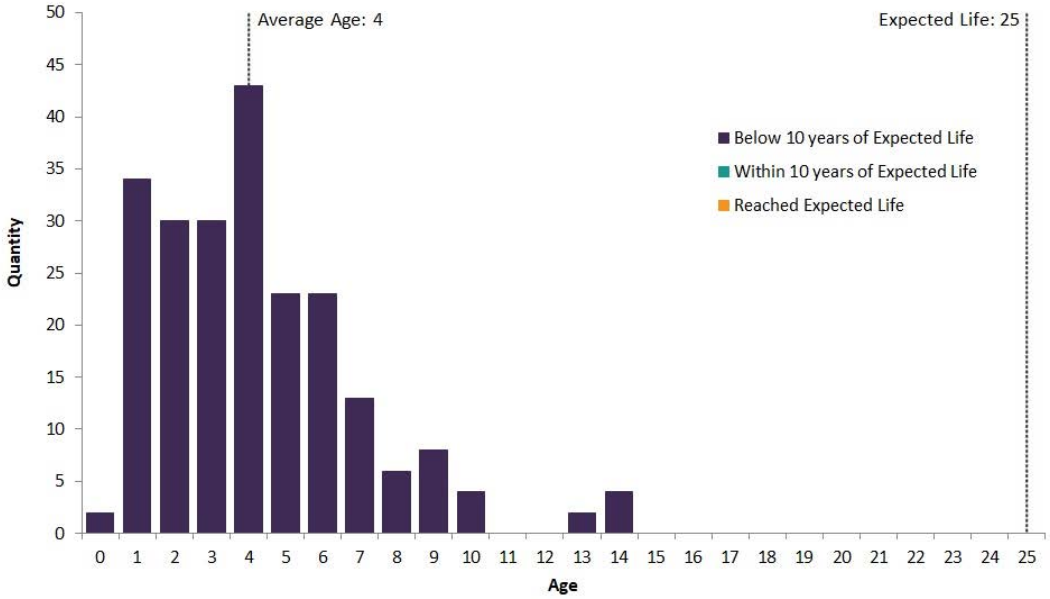


Figure 3: Hydro Ottawa's Distribution Overhead Switch Age Demographics (excluding in-line fuses fused cut-outs)

4. Asset Management Objectives

Distribution overhead switches require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact on system reliability through electrical interruptions affecting a large number of downstream customers
- Achieve reduced number of customers affected through the correct operation of protection devices such as fused cut-outs and reclosers
- Achieve shortened duration outages through the use of reclosers and remote operable switches connected to Hydro Ottawa's supervisory control and data acquisition system
- Achieve quicker reliability restoration as failed overhead switches are easier to locate compared to underground equipment

Health, Safety & Environmental Stewardship

- Impact employee and public safety due to asset failure
- Impact environmental stewardship by releasing oil or gas through asset failure

Asset Value

- Achieve reduced costs due to economic effectiveness of overhead vs. underground distribution
- Achieve protection of equipment such as transformers
- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[3]

Resource Efficiency

- Achieve increased operating productivity through the use of remote operable switches connected to Hydro Ottawa's supervisory control and data acquisition system

In order to monitor and strive to improve the performance of distribution overhead switches, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Overhead Switch KPIs

KPI	*Target*
Overhead switch - SAIFI / 100 customers	3.08[4]
% of overhead load-break/gang-operated switches with health index information[5]	100%
% of overhead load-break/gang-operated switches with very poor health index score	0%

[3] Assumed based on resource and equipment requirements
[4] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual and detailed inspections on its overhead switches. The information from the inspections is used to calculate the overhead switch's health index score through the Asset Condition Assessment (ACA) methodology described in section 6.2. Healthier Indexes are only used for critical switches (load-break/gang- operated switches). Hydro Ottawa has detailed ACA information on 26%[6] of its distribution overhead load-break /gang- operated switches which results in the health indexes shown in Figure 4 below using the ACA methodology.

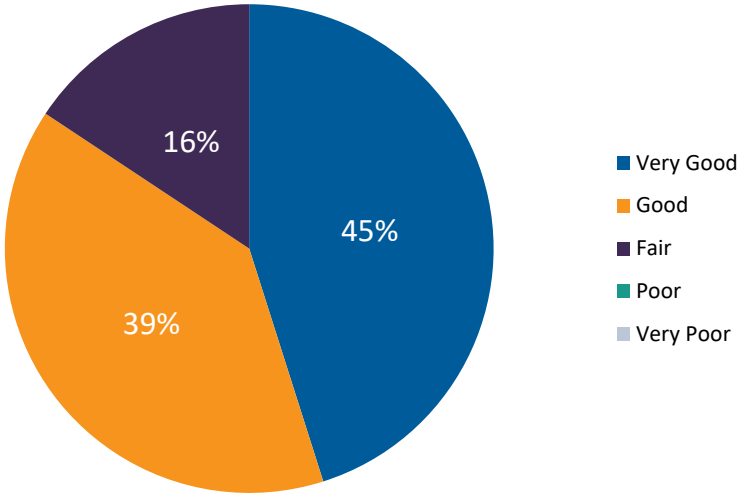


Figure 4: Count of Hydro Ottawa Distribution Overhead Load-Break/Gang-Operated Switches by Condition[6]

Table 4: Distribution Overhead Load-Break/Gang-Operated Switch Condition KPIs

KPI	Target	2018
% of overhead load-break /gang-operated switches with a health index score	**100%**	26%
% of overhead load-break /gang-operated switches with ACA compliant inspections with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of overhead load-break/gang-operated switches with detailed inspections producing health index scores through the ACA methodology. The distribution overhead load-break/gang-operated switch inspection program was initiated in 2018 with a detailed inspection process compliant with ACA requirements. Hydro Ottawa plans to have inspection information to determine a health index for all overhead load-break/gang-operated switches by 2025 as laid out in Table 5.

Table 5: Distribution Overhead Load-Break/Gang-Operated Switch Inspection Plan

KPI	Target	2019	2020	2021	2022	2023	2024	2025
% of overhead load-break / gang-operated switches with health index information	**100%**	37%	48%	60%	71%	82%	93%	100%

[6] Information as of August 2019

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement to reduce the number of outages year-over-year.

Table 6: Distribution Overhead Switch Reliability KPI

KPI	*Target*	*2014*	*2015*	*2016*	*2017*	*2018*
Overhead switch - SAIFI / 100 customers	**3.08**	3.68	1.92	4.02	1.71	4.05

Hydro Ottawa does not currently meets the reliability target for outages due to defective distribution overhead switches and will continue to monitor reliability metrics for trends and improvements.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades overhead switches due to various drivers described in Table 7 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Overhead switches are installed as per approved procedures and standards available in the Overhead and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While generally there is a single driver initiating a project, the affected assets and surrounding area are reviewed to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 7: Drivers for Distribution Overhead Switches Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations, generally relocation is for the supporting pole, or to accommodate an overhead transformer or cable dip for a new service
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customers and third parties. These may include:

Customer Connections

- Upgrade to an existing overhead switch to support service equipment
- New overhead switches installed to support service equipment

Overhead Distribution Switches Relocated

- Relocate overhead switch, driven by relocation of support pole, to accommodate work (e.g. new developments, road expansions) and eliminate clearance concerns or to accommodate a new service transformer or cable dip



Figure 5: Crews Installing Overhead Switch

Table 8 shows the historical overhead switches issued to the field for various activities under System Access.

Table 8: System Access - Distribution Overhead Switches Installed / Replaced / Upgraded

Description	Switch Type	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	Load Break	6	3	1	0	0
	Non-Load Break	67	168	88	76	55
	Recloser	0	0	0	0	0

Description	Switch Type	2014	2015	2016	2017	2018
Assets Relocated	Load Break	0	0	5	0	0
	Non-Load Break	40	53	22	30	27
	Recloser	0	0	0	0	0

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the distribution overhead switches. As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through an overhead switch failure. Hydro Ottawa replaces overhead switches each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff, through visual inspections, the ACA health index results from detailed inspections and feedback from third parties citing concerns. Table 9 shows the historical overhead switches issued to the field for various activities under System Renewal.

Table 9: System Renewal - Distribution Overhead Switches Replaced / Upgraded

Description	Switch Type	2014	2015	2016	2017	2018
Corrective Renewal	Load Break	3	7	2	1	7
	Non-Load Break	45	54	56	69	134
	Recloser	6	8	1	0	1
Planned Renewal	Load Break	1	0	1	11	2
	Non-Load Break	144	218	249	125	90
	Recloser	0	3	4	0	0
Assets Damaged by Third Parties	Load Break	0	0	0	0	0
	Non-Load Break	0	0	12	1	6
	Recloser	0	0	0	0	0

Corrective Renewal
Overhead switches which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual, through IR scanning or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 10. Where applicable, the overhead switches may be upgraded to align with future plans such as adding remote operability to improve reliability.

Table 10: Distribution Overhead Switches Corrective Renewal

Emergency Renewal (Immediate Risk)	Critical Renewal (Imminent Risk)
Damaged Beyond Repair	Loss of Dielectric / Dielectric Breakdown
Inoperable	Irreplaceable Component(s)
Extreme Corona Detected	Insufficient health index (very poor / < 30%)
Health index of 0%	

Planned Renewal

Overhead switches which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews distribution overhead load-break/gang-operated switch's calculated ACA health index and overhead switches in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's overhead switch and recloser renewal program. Also included in the renewal program are switches where issues are identified[7] including chronic issues that interfere with its reliable operation. Additionally, overhead switches may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained.



Figure 6: Overhead Recloser

Assets Damaged by Third Parties

Overhead switches which are damaged due to third parties are replaced immediately after the area is made safe. Historically, this damage has been due to motor vehicle accidents or construction equipment interfering with the overhead switch's supporting pole.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by overhead switch work, but may require overhead switches to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects may include:

Voltage Conversion

- Reduce Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements

- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades

- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Overhead switches are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they need to be replaced, upgraded or installed. Additionally, the condition of the overhead switches is reviewed to determine if replacement due to end-of-life is anticipated. Overhead switches may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 11 shows the historical overhead switches issued to the field for various activities under System Service.

Table 11: System Service – Distribution Overhead Switches Installed / Replaced / Upgraded

Description	Switch Type	*2014*	*2015*	*2016*	*2017*	*2018*
Voltage Conversion	Load Break	29	83	0	69	0
	Non-Load Break	0	6	2	0	7
	Recloser	0	0	0	0	0

[7] Hydro Ottawa Safety, Environment and Business Continuity Notices 19-07, 16-08, 23-10, 27-11 and bulletin 05-18

Description	Switch Type	*2014*	*2015*	*2016*	*2017*	*2018*
System Reliability	Load Break	4	5	14	10	2
	Non-Load Break	32	19	96	111	37
	Recloser	1	0	0	0	0
System Capacity	Load Break	3	1	2	5	3
	Non-Load Break	34	28	17	6	42
	Recloser	0	0	0	1	4

6.2. Operations & Maintenance Plan

Overhead Switch Inspection and Testing

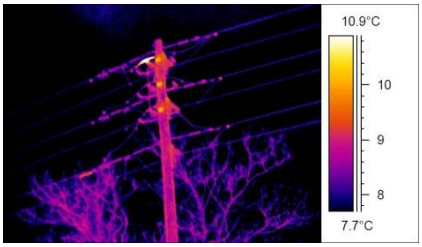


Figure 7: Overhead Switch IR Scan

Hydro Ottawa performs both a predictive visual inspection to report deficiencies and a detailed inspection to capture ACA information on distribution overhead switches. Hydro Ottawa's employees perform predictive visual inspections on overhead switches regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are communicated, so they can be rectified. Hydro Ottawa uses external contractors to perform thermographic scanning following GNG0001 *Guidelines for Thermography* and GCS0015 *Thermographic Scanning of Power Lines and Distribution Apparatus* on a 3-year cycle. Issues found from this inspection are reported to Hydro Ottawa and scheduled for corrective action. Hydro Ottawa also uses external contractors to perform a visual inspection on overhead switches while completing the inspection on the supporting poles following the working procedure OIS0005 *Overhead Line Inspection Method* on a 10-year cycle.

Hydro Ottawa performs detailed inspections on load-break/gang-operated switches due to their criticality within the distribution system following OIS0003 *Overhead Switch Inspection & Maintenance* on an eight year cycle. This information, along with the details from the thermographic scanning, is used to calculate the overall condition of overhead load-break/gang-operated switches by calculating a health index using the ACA described in GEG0001 *Asset Health Index Guideline*. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Overhead Switch Repairing

Hydro Ottawa performs reactive maintenance and repair to overhead switches and planned maintenance to load-break/gang-operated switches when there are repairable issues which don't classify the overhead switch as reaching its end-of-life. Typical repairs include replacement of minor components, motor operator or control box parts that may have been damaged through the switch's normal operation, re-tightening of connections and performing minor adjustments to the switch's mechanism.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses distribution overhead switches depending on their condition when they are removed from service due to various drivers. Where an overhead switch is removed from service, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. The oil or gas used for insulation is disposed of based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains stock of distribution overhead switches which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 10. This stock allows Hydro Ottawa to replace overhead switches in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of over 207 overhead switches (including cut-outs, single-phase in-line switches, clustered switches, horizontal and vertical gang-operated load-break switches),), and 13 reclosers of various types, configurations, voltages, and sizes to enable Hydro Ottawa to replace these assets on an emergency basis. The minimum quantity of overhead switches is based on the asset's usage and the need to have replacement assets should an emergency occur. Furthermore, certain switches are installed with a bypass such that if a switch fails or requires prolonged maintenance, the line can be energized, but with reduced flexibility in system configuration while the switch is maintained or replaced.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of overhead switches and reclosers should an issue arise or more assets be required. Additionally, this includes using contractors beyond normal scopes of work to assist Hydro Ottawa crews in asset installation during emergencies.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual overhead switches to be installed, replaced or upgraded are shown in Table 12.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms (e.g. Public Service Works on Highways Act).

Table 12: Forecasted System Access - Distribution Overhead Switches Installed/Replaced/Upgraded

Description	Switch Type	*2019**	*2020**	*2021**	*2022**	*2023**	*2024**	*2025**
Customer Connection	Load Break	2	2	2	2	2	2	2
	Non-Load Break	91	91	91	91	91	91	91
	Recloser	0	0	0	0	0	0	0
Assets Relocated	Load Break	1	1	1	1	1	1	1
	Non-Load Break	34	34	34	34	34	34	34
	Recloser	0	0	0	0	0	0	0

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by failed assets and information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue with existing inspections and therefore forecasts the future demand of overhead switches replaced due to corrective renewal to be in line with historical averages. Overhead switches replaced due to assets damaged by third parties are forecasted based on historical averages.

Hydro Ottawa plans to replace overhead load-break gang-operated switches which result in a poor condition (health index score of >=30% and < 50%) through detailed inspections. Additionally, Hydro Ottawa proactively replaces switches where issues have been identified, such as obsolescence of parts, which may have a future negative affect on the switch's ability to deliver on the asset management objectives. The expected annual overhead switches to be replaced or upgraded are shown in Table 13.



Figure 8: Overhead Switch Installation

Table 13: Forecasted System Renewal – Distribution Overhead Switches Replaced/Upgraded

Description	Switch Type	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal	Load Break	4	4	4	4	4	4	4
	Non-Load Break	78	78	78	78	78	78	78
	Recloser	3	3	3	3	3	3	3
Planned Renewal	Load Break	126	0	0	0	0	0	0
	Non-Load Break	58	0	0	375	375	398	0
	Recloser	0	0	0	0	0	0	0
Assets Damaged by Third Parties	Load Break	0	0	0	0	0	0	0
	Non-Load Break	5	5	5	5	5	5	5
	Recloser	0	0	0	0	0	0	0

*Estimated Quantities

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require distribution overhead switches to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for overhead switches is shown in Table 14.

Table 14: Forecasted System Service – Distribution Overhead Switches Replaced / Upgraded / Installed

Description	Switch Type	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	Load Break	25	1	0	25	15	6	0
	Non-Load Break	0	3	0	0	0	0	0
	Recloser	0	0	0	0	0	0	0
System Reliability	Load Break	0	0	0	3	67	4	8
	Non-Load Break	4	9	0	0	0	6	12
	Recloser	0	0	0	0	0	0	0
System Capacity	Load Break	14	23	4	0	27	0	0
	Non-Load Break	4	2	22	9	0	0	0
	Recloser	0	0	0	0	0	0	0

*Estimated Quantities

7.4. External Factors

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to overhead switches. Freezing rain, ice storms and high wind events have the capacity to exceed the overhead distribution switch's design limits. Additionally, these events have the potential to exceed the supporting pole and conductor's design limits which can lead to damaged overhead switches. Continued system monitoring and forecasting are required to ensure overhead switches continue to operate safely and provide value through delivering the asset management objectives.

Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to overhead switchgear, and there are no current climate specific adaptations for this asset. This assessment will be periodically reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. overhead) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Distribution overhead switch assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 25 years. The difference between the expected operating life and the financial useful life is that certain drivers require overhead switches to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project. The expected operating life and financial life for overhead switches are the same.

The existing net book value of Hydro Ottawa's distribution overhead switches is approximately $6.8M[8] which represents 1.0% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Therefore the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's distribution overhead switches is approximately $1.6M[8].

[8] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa continues to consider additional key performance indicators (KPIs) and monitor existing KPIs to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of distribution overhead switches in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with overhead switches.

Hydro Ottawa also addresses issues with distribution overhead switch assets through the overhead standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards with respect to overhead assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

As part of striving towards a proactive inspection and maintenance program for overhead assets, Hydro Ottawa is presently developing an inspection program to provide an ACA compliant condition rating for reclosers.

Furthermore, Hydro Ottawa actively trials new types of overhead switches for reasons such as increased resilience, ease of operation and ease of maintainability. One such example is the trial of the Vector branded switch to determine its utility as a gang-operated load-break switch; trials with positive outcomes such as this, as this switch is expected to receive technical approval over the coming year, gives Hydro Ottawa additional options when it comes to both new construction and its planned renewal programs.

Additionally, as part of improving maintenance practices, Hydro Ottawa has been developing a program that will test the remote operation of all remotely operated switches twice annually. This structured program and switch cycle will ensure that remotely operated overhead switches function as intended.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 - *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution overhead switches achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

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APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Distribution Overhead Transformers

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-02-22	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



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1. Introduction

Hydro Ottawa's distribution overhead transformers are used to Modify voltage levels for distribution and supply to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management Plan*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - OIS0005 - *Overhead Line Inspection Method*
Hydro Ottawa - GCS0015 - *Thermographic Scanning of Power Lines and Distribution Apparatus*
Hydro Ottawa - WTS0002 - *Testing Used Distribution Transformers*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - E&O intranet website - *Overhead Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Overhead Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Overhead Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Overhead Qualifications*
Hydro Ottawa - E&O intranet website - *Overhead Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Overhead Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Overhead Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
CSA C22.3 No.1: *Overhead Systems*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001
Government of Canada - SOR/2008-273 - *PCB Regulations*

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's distribution overhead transformer assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of overhead transformers can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to overhead transformers includes the components below which allow for the successful use of the asset.

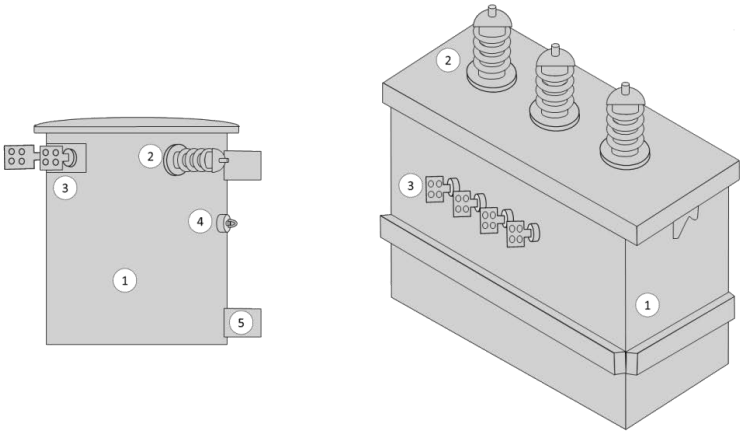


Figure 1: Distribution Overhead Transformer (Illustrative Purposes Only)

Table 1: Distribution Overhead Transformer Functions

Figure Number	Component	Function
1	Enclosure	Distribution overhead transformer enclosures maintain isolation of the medium and low voltage equipment from outside sources while ensuring security from the public for increased safety. Additionally, the enclosure protects the inside equipment from damage and increases system reliability by isolating it from weather, animals and contaminants.
2	Primary Bushing	Primary bushings support an insulated flow of current from the connecting primary overhead conductor to the inside connections through the grounded enclosure.
3	Secondary Bushings	Secondary bushings support an insulated flow of current from the inside connections through the grounded enclosure to the secondary conductor.
4	Tap Changer	The tap changer is used to regulate the voltage of the distribution overhead transformer by changing the transformer's winding ratio. The tap changer can rotate up or down to either increase or decrease the ratio. This ensures that the voltage supplied by transformer is constant, even in cases where the incoming voltage is high or low. This results in the distribution of high-quality power.
5	Hanging Lugs	Hanging lugs are used to mount distribution overhead transformers, such as to poles.
Not Shown	Ground Connection	The ground connection allows for a low impedance path for current to ground to limit buildup of unsafe voltage on the electricity system and equipment.
Not Shown	Surge Arrestors	Surge arresters protect the distribution overhead transformer by supressing voltage surges from various causes (e.g. lightning).

Table 2: Class, Sub-class and Components of Distribution Overhead Transformers

Class	Sub-Class	Components Belonging to or Supporting the Sub-Class
Overhead Transformer	Single Phase Transformer	Enclosure, Core, Windings, Bushings, Arrestors, Paper Insulation, Insulating Oil, Tap Changer and Pressure Relief Valve
	Banked Single Phase Transformers	Enclosure, Core, Windings, Bushings, Arrestors, Paper Insulation, Insulating Oil, Tap Changer and Pressure Relief Valve
	Three Phase Transformer	Enclosure, Core, Windings, Bushings, Arrestors, Paper Insulation, Insulating Oil, Tap Changer and Pressure Relief Valve

Hydro Ottawa owns 15,619[2] distribution overhead transformers throughout the service territory. While the majority of overhead transformers are single phase units, Hydro Ottawa also owns banked single phase units and three phase overhead transformers to provide customers with their required service voltage. The demographics of these configuration types are shown in Figure 2.

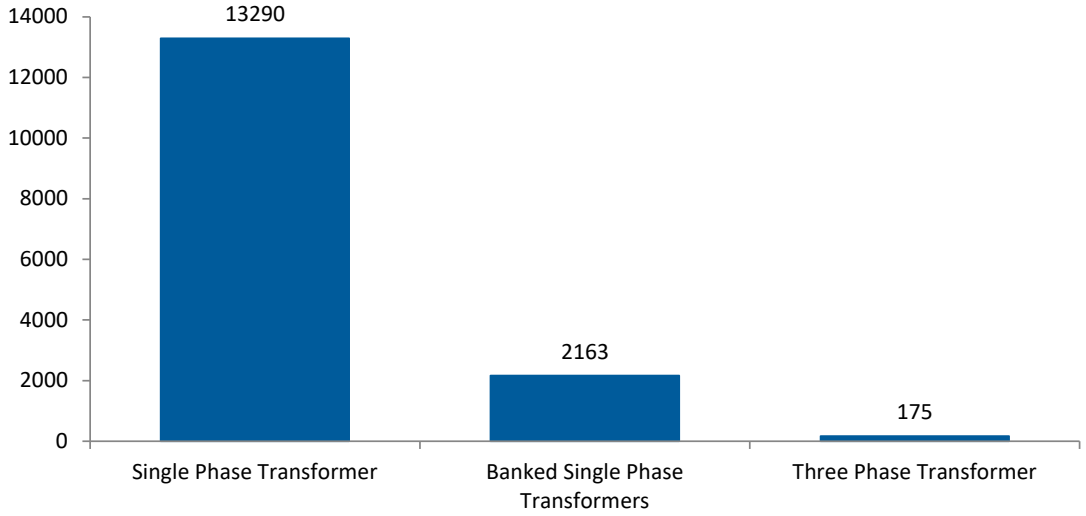


Figure 2: Count Hydro Ottawa's Distribution Overhead Transformers by Sub-Class[2]

Currently, Hydro Ottawa has known and estimated purchase dates or installation dates stored in the Geographic Information System (GIS) for approximately 88%[2] of its distribution overhead transformers. The overall demographics of overhead transformers with a known age are shown in Figure 3 below. The expected operating life of overhead transformers, where the probability of failure is approximately 2% or greater, is 53 years.

[2] Information as of September 2019

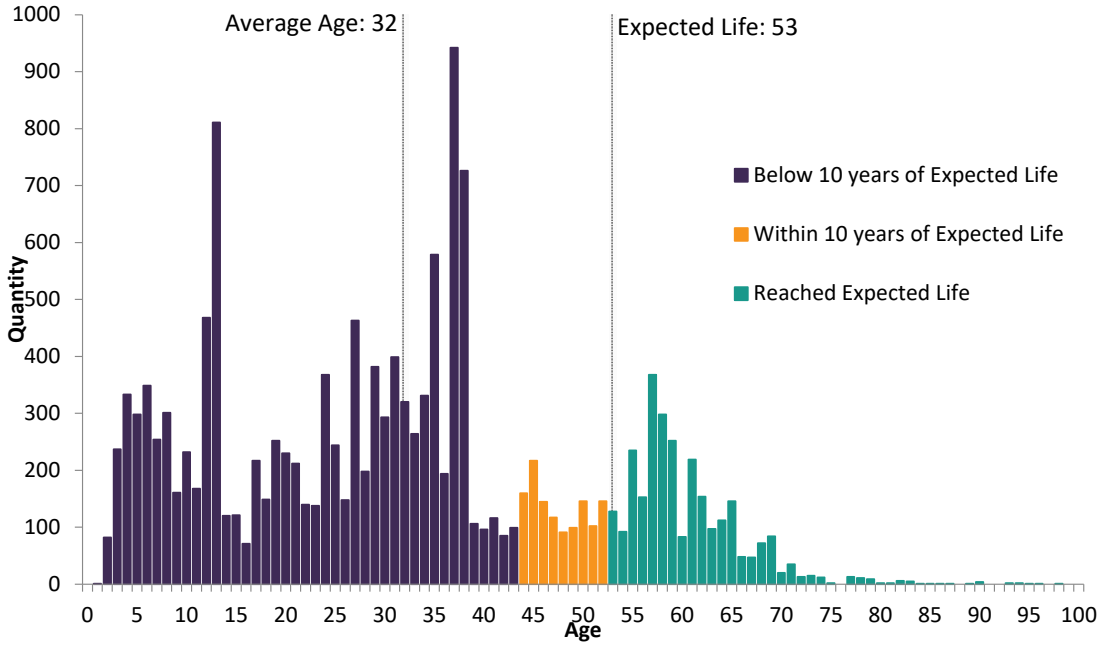


Figure 3: Count of Hydro Ottawa's Distribution Overhead Transformers by Age[2]

4. Asset Management Objectives

Distribution overhead transformers require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Achieve the transformation of electrical voltage to a level usable by customers
- Impact on system reliability through electrical interruptions which may be localized, affecting customers connected to that specific overhead transformer, or a wider outage, affecting a large number of customers supplied by the connecting conductors
- Achieve suitable power quality through the use of tap changers
- Achieve quicker reliability restoration as failed overhead transformers are easier to locate compared to underground equipment

Health, Safety & Environment Stewardship

- Impact employee and public safety due to rusted tank which can lead to leaking oil
- Impact environmental stewardship by releasing oil through asset failure

Asset Value

- Achieve reduced costs due to economic effectiveness of overhead vs. underground distribution
- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[3]

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually has multiple overhead transformers in the same area[3]

Compliance

- Impact compliance with the Government of Canada - SOR/2008-273 - PCB Regulations

In order to monitor and strive to improve the performance of distribution overhead transformers, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Overhead Transformers KPIs

KPI	*Target*
Overhead transformer - SAIFI / 100 customers	0.18[4]
% of overhead transformers with health index information[5]	100%
% of overhead transformers with very poor health index score	0%
% of overhead transformers containing non-compliant PCB oil	0%

[3] Assumed based on resource and equipment requirements
[4] Based on a five (5) year average
[5] Asset health index KPI is based on timely data, that is, in line with the inspection cycle in GCS0015 *Thermographic Scanning of Power Lines and Distribution Apparatus*

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections on its overhead transformers; note other types of overhead voltage transformation and regulation assets, including distribution step transformers and distribution voltage regulators, are managed outside of a planned program of inspection. The information from the detailed inspections is used to calculate the overhead transformer's health index score through the Asset Condition Assessment (ACA) methodology described in Section 6.2. This includes assessing equipment and connection issues using infrared (IR) scanning. Additionally, detailed visual inspections are completed within the planned pole inspection program discussed in the Pole, Fixture and Primary Overhead Conductor AMP. Detailed IR scans are performed on a rotating 3 year cycle and the detailed visual inspections are performed on a rotating 10 year cycle. Hydro Ottawa has detailed inspection information on 41%[6] of its distribution overhead transformers which results in health indexes shown in Figure 4 below using the ACA methodology.

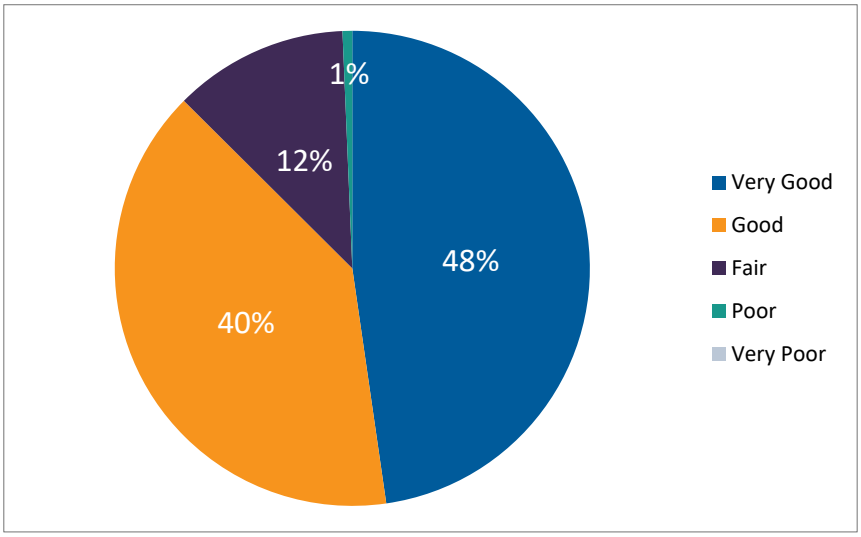


Figure 4: Count of Distribution Overhead Transformers with health index scores by Condition[6]

Table 4: Overhead Distribution Transformer Condition KPIs

KPI	Target	2018
% of overhead transformers with a health index score	**100%**	41%
% of overhead transformers with ACA compliant inspections with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of overhead transformers with detailed inspections producing health index scores through the ACA approach. The distribution overhead transformer inspection program was renewed in 2016 with a detailed inspection process compliant with ACA requirements and is performed in concert with the planned pole inspection program. Hydro Ottawa plans to have inspection information to determine a health index for all overhead transformers by 2024 (following the 10 year cycle) as laid out in Table 5.

[6] Information as of October 2019

Table 5: Distribution Overhead Transformer Inspection Plan[7]

KPI	Target	2019	2020	2021	2022	2023	2024
% of overhead transformers with health index information	**100%**	51%	61%	71%	81%	91%	100%

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement to reduce the number of outages year-over-year.

Table 6: Distribution Overhead Transformer Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Overhead transformer - SAIFI / 100 customers	**0.18**	0.05	0.49	0.13	0.11	0.10

Hydro Ottawa currently meets the reliability target for outages due to defective distribution overhead transformers and will continue to monitor reliability metrics for trends and improvements.

5.3. Compliance

Hydro Ottawa prioritized the inspection and oil sampling of distribution overhead transformers shortly after the Government of Canada enacted regulations on the manufacturing and use of oil containing PCBs. The inspection and oil sampling allowed Hydro Ottawa to determine which assets required replacing to meet the legislative requirements.

Table 7: Distribution Overhead Transformer Compliance KPI

KPI	Target	2018
% of overhead transformers containing non-compliant PCB oil	**0%**	0%[8]

Hydro Ottawa has met the compliance target for removing all distribution overhead transformers which contained oil with PCB levels above that specified in the Government of Canada's - SOR/2008-273 - PCB Regulations.

[7] Inspection data assumes same trend as pole inspections – 10 year cycle

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades overhead transformers due to various drivers described in Table 8 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Overhead transformers are installed as per approved procedures and standards available in the Overhead and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While generally there is a single driver initiating a project, the affected assets and surrounding area are reviewed to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 8: Drivers for Distribution Overhead Transformer Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations, generally relocation is for the supporting pole
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. These may include:

Customer Connections

- Upgrade an existing overhead transformer to support service equipment
- New overhead transformer installed to support service equipment – temporary and permanent

Relocated Assets

- Relocate overhead transformer, typically driven by the relocation of the support pole, to accommodate work (e.g. new developments, road expansions) and eliminate clearance concerns

Table 9 shows the historical overhead transformers issued to the field for various activities under System Access.



Figure 5: Overhead Transformer

Table 9: System Access – Overhead Distribution Transformers Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	76	88	77	88	79
Assets Relocated	18	13	23	19	8

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the distribution overhead transformer. As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through an overhead transformer failure. Hydro Ottawa replaces overhead transformers each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff, through visual inspections, the ACA health index results from detailed inspections and feedback from third parties citing concerns. Table 10 shows the historical overhead transformers issued to the field for various activities under System Renewal.

Table 10: System Renewal – Distribution Overhead Transformer Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Corrective Renewal	134	124	141	164	71
Planned Renewal	66	152	108	70	51
Assets Damaged by Third Parties	1	2	5	2	3

Corrective Renewal
Overhead transformers which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual, through IR scanning or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 11. Where applicable, the overhead transformer may be upgraded to align with future plans such as increasing capacity for future customers.



Figure 6: Broken Support Structure and Transformer

Table 11: Distribution Overhead Transformer Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	*Critical Replacement (Imminent Risk)*
Damaged beyond repair	Cracked / broken bushing
Leaking oil	Insufficient health index (very poor / < 30%)
Overheating (identified through IR scan)	
Popped pressure indicator	
Health index of 0%	

Planned Renewal
Overhead transformers which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews distribution overhead transformer's calculated ACA health index and overhead transformers in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's overhead transformer renewal program. Additionally, overhead transformers may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained.

Assets Damaged by Third Parties
Overhead transformers which are damaged due to third parties are replaced immediately after the area is made safe. Historically, this damage has been due to motor vehicle accidents or construction equipment interfering with the overhead transformer's supporting pole.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by overhead transformer work, but may require overhead transformers to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects may include:



Figure 7: Overhead Transformer Bank

Voltage Conversion

- Reduce Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements

- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades

- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Overhead transformers are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they need to be replaced, upgraded or installed. Additionally, the condition of the overhead transformers is reviewed to determine if replacement due to end-of-life is anticipated. Overhead transformers may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 12 shows the historical overhead transformers issued to the field for various activities under System Service.

Table 12: System Service – Distribution Overhead Transformers Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Voltage Conversion	69	99	23	28	1
System Reliability	0	4	22	17	4
System Capacity	10	8	0	0	1

6.2. Operations & Maintenance Plan

Overhead Transformer Inspection and Testing

Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and a detailed inspection to capture ACA information on distribution overhead transformers. Hydro Ottawa's employees perform passive visual inspections on overhead transformers regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are communicated per the principles described in the working procedure OIS0001*Overhead Distribution System Inspection* so the issue can be rectified. Hydro Ottawa also uses external contractors to perform IR scanning following GNG0001*Guidelines for Thermography* and *GCS0015 Thermographic Scanning of Power Lines and Distribution Apparatus*. Issues found from this inspection are reported to Hydro Ottawa and actioned for remedy.

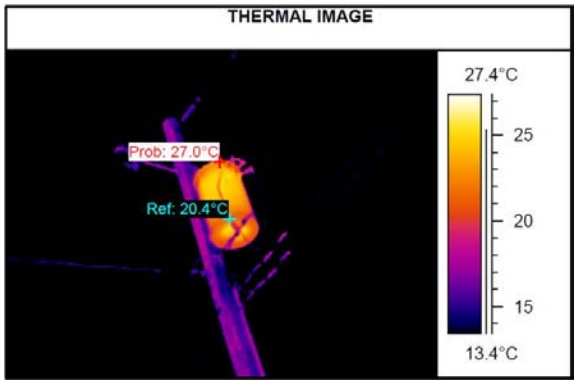


Figure 8: Overhead Transformer Infrared Scan

Hydro Ottawa uses external contractors to perform a detailed inspection on overhead transformers while completing the inspection on the supporting poles following the working procedure OIS0005 *Overhead Line Inspection Method*. This information, along with the details from the IR scanning, is used to calculate the overall condition of overhead transformers by calculating a health index using the ACA described in GEG0001*Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the overhead transformer's condition. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Overhead Transformer Repair
Hydro Ottawa performs reactive maintenance and repair to overhead transformers when there are minor issues which don't classify the overhead transformer as reaching its end-of-life (through the inspection process mentioned above). Typical repairs include replacing failed components which make up the overhead transformer.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses distribution overhead transformers depending on their condition when they are removed from service. Hydro Ottawa only re-uses overhead transformers following the testing and inspection per the previously mentioned inspection methods and WTS0002 *Testing Used Distribution Transformers*. The testing also determines whether to send the overhead transformer to the supplier for refurbishment where Hydro Ottawa recovers value. Where an overhead transformer is scrapped, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. The oil used for insulation is disposed of based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of distribution overhead transformers which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 11. This stock allows Hydro Ottawa to replace such overhead transformers in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of over 216 overhead transformers of various configurations, voltages, and sizes to be used during emergencies. Additionally, Hydro Ottawa stocks numerous quantities of various types of overhead transformer components. The minimum quantity of overhead transformers is based on the asset's usage and the need to have replacement assets should an emergency occur.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of overhead transformers should an issue arise or more assets be required. Additionally, this includes using contractors beyond normal scopes of work to assist Hydro Ottawa crews in asset installation during emergencies.



Figure 9: Hydro Ottawa Overhead Transformer Stock

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in Section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual overhead transformers to be installed, replaced or upgraded are shown in Table 13.



Figure 10: Overhead Transformer Installation

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms (e.g. Public Service Works on Highways Act).

Table 13: Forecasted System Access - Distribution Overhead Transformers Installed/Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	82	82	82	82	82	82	82
Assets Relocated	16	16	16	16	16	16	16

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by failed assets and based on information provided through inspections as described in Sections 6.1.2 and 6.2, and compliance with regulator's requirements including the Electrical Safety Authority. Hydro Ottawa plans to continue with existing inspections and therefore forecasts the future demand of overhead transformers replaced due to corrective renewal to be in line with historical averages. Overhead transformers replaced due to assets damaged by third parties are forecasted based on historical averages.



Figure 11: Old Overhead Transformer

Hydro Ottawa plans to proactively replace overhead transformers which result in a poor condition (health index score of >=30% and < 50%) through detailed inspections. Additionally, due to the risk posed by the number of overhead transformers in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined the number of overhead transformers which require proactive replacement to mitigate the risk. This replacement strategy will prioritize overhead transformers based on their ACA results and balance the future replacement of the growing and aging fleet of assets. This approach allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual overhead transformers to be replaced or upgraded are shown in Table 14.

Table 14: Forecasted System Renewal – Distribution Overhead Transformers Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal**	122	122	122	122	122	122	122
Planned Renewal	90	90	90	90	90	90	90
Assets Damaged by Third Parties**	3	3	3	3	3	3	3

*Estimated Quantities
**Based on 5 year historical data ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in Section 6.1.3. System improvement drivers may require distribution overhead transformers to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for overhead transformers is shown in Table 15.

Table 15: Forecasted System Service – Distribution Overhead Transformers Replaced / Upgraded / Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	8	9	0	23	38	7	0
System Reliability	4	1	0	6	0	0	0
System Capacity	13	0	8	3	15	0	0

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact distribution overhead transformers and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to overhead transformers. During the summer months where system electricity demand is already the highest compared to the rest of the year, increased heat and corresponding electrical responses, such as air conditioning, can put strain on system equipment including overhead transformers. An increasing occurrence of high heat conditions, coupled with continued electrical demand growth can increase the heat experienced by these transformers, causing equipment overloading and accelerated failure. Continued system monitoring and forecasting are required to ensure overhead transformers continue to operate safely and provide value through delivering the asset management objectives. Additionally, freezing rain, ice storms and high wind events have the capacity to exceed the supporting pole's design limits. These events can damage supporting assets leading to damaged overhead transformers and a reduction in Hydro Ottawa's levels of service and public and employee safety.

Furthermore, Hydro Ottawa is undertaking a distribution system climate vulnerability risk assessment and developing a Climate Change Adaptation Plan with the support of an external consultant. The results of this assessment will be used to assess and update Hydro Ottawa's various practices and standards

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. overhead transformer renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. overhead) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Distribution overhead transformer assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 35 years. The difference between the expected operating life and the financial useful life is that certain drivers require overhead transformers to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

Hydro Ottawa does not track the net book value of distribution overhead versus underground transformers separately. The existing net book value of Hydro Ottawa's distribution overhead and underground transformers is approximately $48.9M[9] which represents 7.2% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy* (i.e. straight line depreciation); therefore, the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's distribution overhead and underground transformers is approximately $7.3M[9].

[9] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of distribution overhead transformers in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with overhead transformers.

Hydro Ottawa also addresses issues with distribution overhead transformers through the overhead standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to overhead assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

Furthermore, Hydro Ottawa is in the process of levelizing overhead transformer replacement as described in Section 7.2 to allow for more predictive forecasting of cost and labour requirements.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 - *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution overhead transformers achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
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APPROVED:	L. Heuff		
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Asset Management Plan
Civil Structures

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-01-11	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
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Asset Management Plan – Civil Structures

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1. Introduction

Hydro Ottawa's civil structure assets are used to safely and reliably support the transformation and delivery of electricity to customers throughout the service territory. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - *Distribution System Plan*
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management Plan*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - UIS0001 - *Padmount/Kiosk Transformer Inspection Procedure*
Hydro Ottawa - UIS0002 - *Padmount Switchgear Inspection Procedure*
Hydro Ottawa - UIS0004 - *Underground Cable Chamber Inspection Procedure*
Hydro Ottawa - E&O intranet website - *Underground Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Underground Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Underground Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Underground Qualifications*
Hydro Ottawa - E&O intranet website - *Underground Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Underground Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Underground Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - PRO-HEA-014 - *Asbestos Management Program*
Hydro Ottawa - WI-HEA-003 – Asbestos Cable Wrap Removal in Manholes
Hydro Ottawa - WI-ENV-020 - Asbestos Transport and Storage
Hydro Ottawa - WI-HEA-004 - Asbestos Cable Wrap Removal Using Glove Bags
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's civil structures which includes cable chambers (typically referred to as manholes), hand holes, equipment pads, duct banks and other minor civil structures that are not actively managed such as bollards. Note that civil structures specifically used to support a distribution asset, including pads, transformer and switchgear manholes, and bollards, are managed as part of the distribution they support. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of various civil structures can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to various civil structures includes the components below which allow for the successful use of the asset.

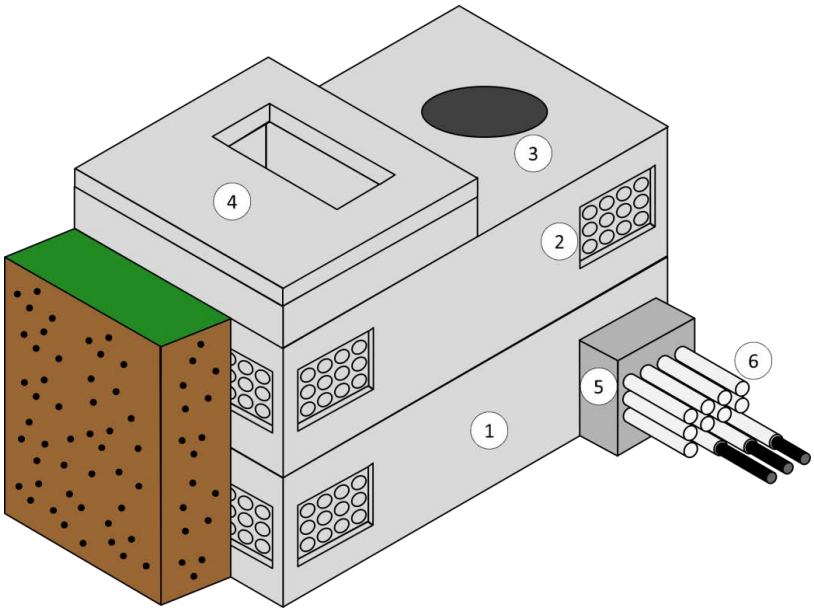


Figure 1: Cable Chamber (Illustrative Purposes Only)

Table 1: Civil Structure Functions

Figure Number	Component	Function
1	Cable Chamber	Cable chambers are used to protect other assets such as cable and submersible equipment from external damage and elements. The cable chamber also provides an area for cable splicing, cable pulling, and for replacement and repair without excavation.
2	Duct Windows	Duct windows are pre-cast concrete structures used for installing new ducts within a cable chamber, while providing a space for future ducts and ease of future core drills.
3	Cable Chamber Entrance/Lid	The cable chamber entrance/lid allows access to within the cable chamber to gain access to underground assets and connections.
4	Equipment Pad	Pads support pad-mounted assets including transformers and switchgear. They also allow for bottom entry of equipment and equipment terminations.

Figure Number	Component	Function
5	Concrete Encased Duct Bank	Concrete encased duct banks support electrical conductors, protect ducts, and therefore the associated cables through a physical barrier preventing damage.
6	Duct	Duct supports and protects electrical conductors, while allowing for ease of pulling new cable

Table 2: Class, Sub-class and Components of Distribution Overhead Transformers

Class	*Sub-Class*	Components Belonging to or Supporting the Sub-Class
Civil Structure	Cable Chamber	Concrete, Rebar, Duct Windows, Cable Chamber Entrance, Cable Chamber Lid, Cable Racking, Grounding
	Switching Cable Chamber	Concrete, Rebar, Duct Windows, Cable Chamber Entrance, Cable Chamber Lid, Cable Racking, Grounding , Equipment Pad
	Equipment Pad	Concrete, Rebar, Equipment Connection Window
	Direct Buried Duct	Duct, Spacers
	Concrete Encased Duct	Concrete, Rebar, Duct, Spacers

Hydro Ottawa owns 3,878 cable chambers[2], 406 handholes[2], 18,645 pads[2], and 8,942km of duct conduit[2]. Hydro Ottawa actively manages both cable chambers and pads through planned inspection programs. Handholes and ducts are maintained or replaced reactively along with other work or following an asset failure. Given the costs associated with obtaining information and testing both ducts and handholes, and considering the low impact associated with failure of those assets, Hydro Ottawa does not actively monitor health of ducts and handholes. Additionally, the inspection of underground ducts could also lead to an increased risk of damage through excavation, further negating the value of obtaining health information. Content of the AMP beyond this section refers primarily to cable chambers and pads.

Hydro Ottawa's cable chambers are constructed either as pre-cast or cast in place as shown in Figure 2. Currently, Hydro Ottawa has installation dates stored in the Geographic Information System (GIS) for approximately 74%[2] of its cable chambers. Installation information for pads is typically aligned with the information for the supported equipment found in the equipment's respective AMP. The overall known age demographics of cable chambers are shown in Figure 3 below. The expected operating life of cable chambers, where the probability of failure is approximately 2% or greater, is an effective age of 52 years.

[2] Taken from 2018 Draft Quick Facts

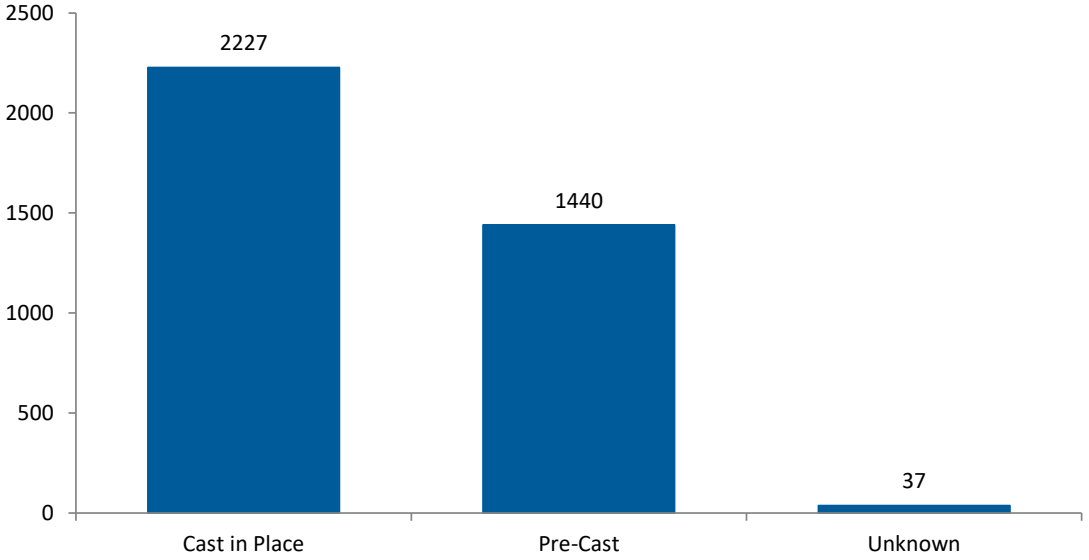


Figure 2: Hydro Ottawa Cable Chamber Demographics[3]

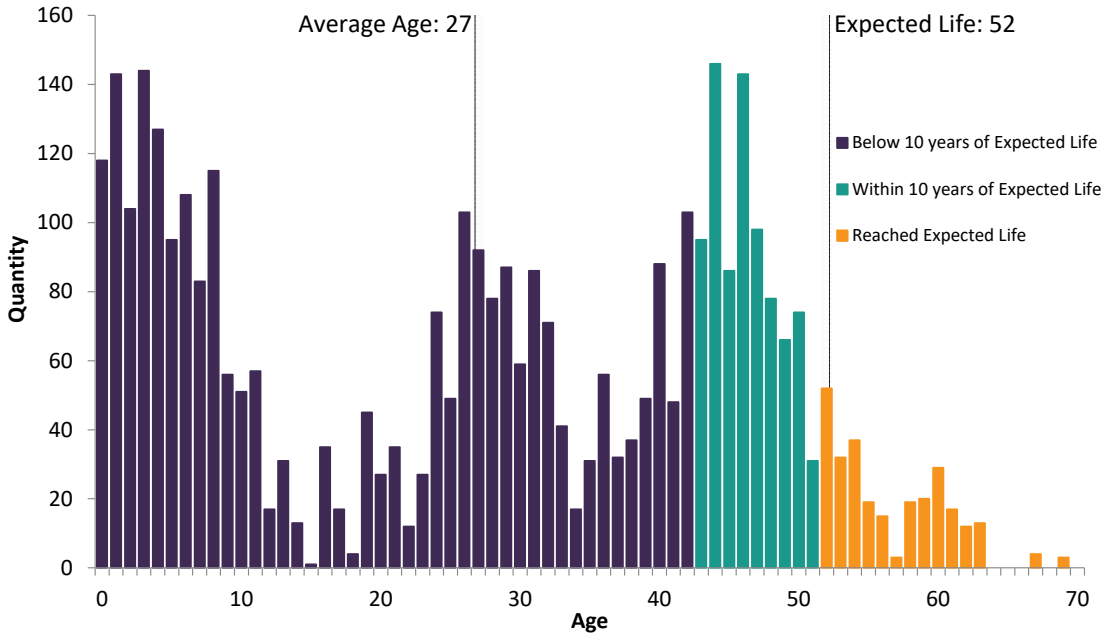


Figure 3: Hydro Ottawa's Cable Chamber Age Demographics[3] Based on Original Installation Date

[3] Information as of July 2018

4. Asset Management Objectives

Civil structures require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact service quality due to an electrical interruption which may be a contained outage affecting customers served by that specific civil structure, or a larger outage affecting customers supplied by the conductors passing through it, reducing system reliability

Health, Safety & Environmental Stewardship

- Impact employee and public safety due to holes (or gaps) in the civil structure, allowing access to energized components, fall/trip hazards, collateral damages to vehicles
- Achieve asbestos removal in conjunction with removal of duct bank(s)

Asset Value

- Impact asset lifecycle cost as an emergency replacement is more costly than a planned replacement[4]
- Impact supported asset's lifecycle cost due to lack of appropriate support structure
- Achieve cable protection and access to complete work
- Achieve replacement efficiencies and reduced effort in cable pulling
- Impact on cost of future expansion by creating designed spare capacity

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually has multiple civil structures in the same geographic location[4]

In order to monitor and strive to improve the performance of civil structures, Hydro Ottawa reviews the Key Performance Indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation. There are no KPIs associated with pads as ACA health scores are not individually developed for pads. However, the pads are actively inspected as part of the inspection for the equipment in which the pad supports.

Table 3: Civil Structures KPIs

KPI	*Target*
SAIFI / 100 customers	0.0[5]
% of cable chambers with health index information	100%
% of cable chambers with very poor health index score	0.0%

[4] Assumed based on resource and equipment requirements
[5] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections on its civil structures. The information from the detailed inspections is used to calculate civil structure's health index through the Asset Condition Assessment (ACA) described in section 6.2. The detailed inspections (active visual inspection complete with sounding tests) for cable chambers are completed on a 10-year cycle where areas with older cable chambers or known issues are prioritized. Hydro Ottawa has detailed inspection information on 72%[6] of its cable chambers which results in health indexes shown in Figure 4 below using the ACA methodology. Visual inspections are completed on pads on a 3 year cycle as part of the visual inspection for padmounted equipment. This assessment taken into consideration is accounted for in the padmounted equipment's condition and in many cases the supported asset has a shorter expected operating life than the civil support structure.

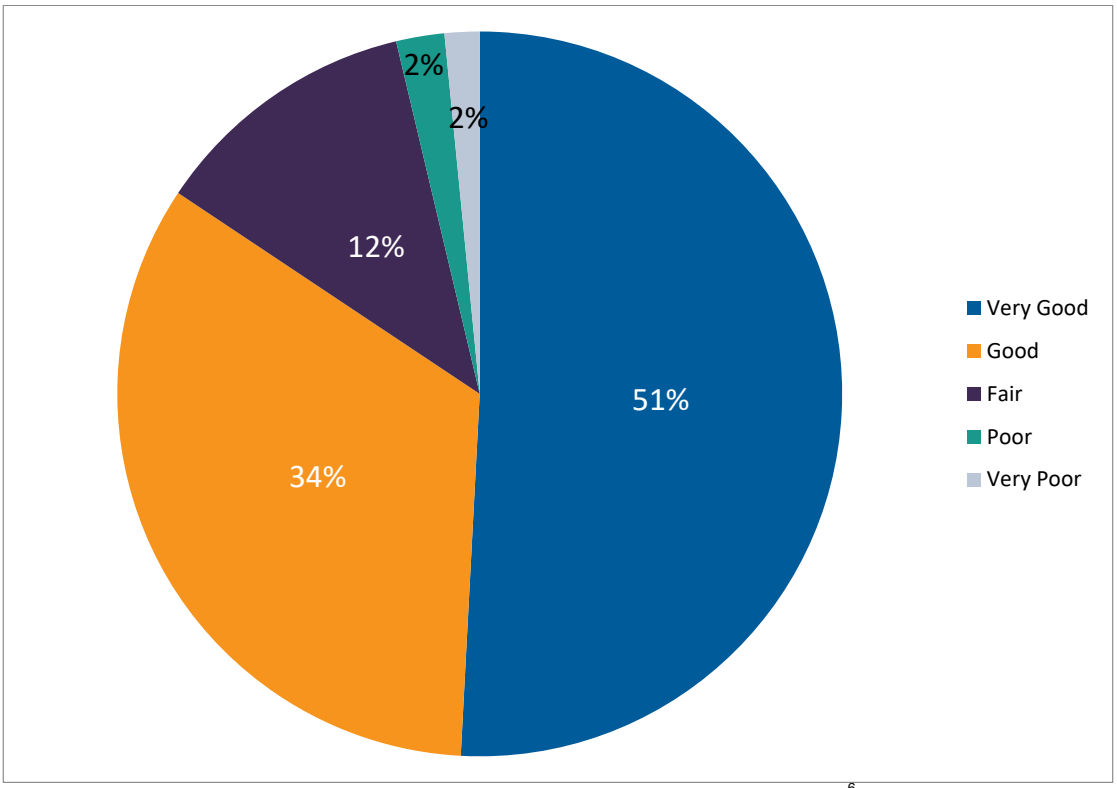


Figure 4: Count of Hydro Ottawa Cable Chamber by Condition[6]

Table 4: Cable Chamber Condition KPIs

KPI	Target	2018
% of cable chambers with a health index score	**100%**	72%
% of cable chambers with ACA compliant inspections with a very poor health index score	**0.0%**	0.01%

[6] Information as of May 2018

Hydro Ottawa currently does not meet the target of cable chambers with detailed inspection producing health index scores through ACAs shown in Table 4. The cable chamber inspection program was being renewed in 2018 with an established detailed inspection cycle compliant to the ACA process for all cable chambers. Hydro Ottawa plans to have inspection information to determine a health index for all chambers by 2027.

Table 5: Cable Chamber Inspection Plan

KPI	Target	2019	2020	2021	2022	2023	2024	2025	2026	2027
% of cable chambers with health index information[7]	**100%**	59%	64%	69%	74%	79%	84%	89%	95%	100%

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Correlation of asset reliability performance to condition is difficult for civil structures as an inspection can identify a structure which is unable to perform its function to a level acceptable to Hydro Ottawa without resulting in a decrease to Hydro Ottawa's levels of service. This is due to civil structures serving as part of the distribution system's foundations rather than directly delivering power. Therefore a failed civil structure may not result in an immediate outage to the customer. However, a failed civil structure may result in increased safety risks due to reduced structural strength.

Table 6: Civil Structure Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Underground Civil Structures - SAIFI / 100 customers	**0.0**	0.0	0.0	0.0	0.0	0.0

Hydro Ottawa currently meets the reliability target for outages due to defective civil structures and will continue to monitor reliability metrics for trends and improvements.

[7] Yearly estimates are based on straight line data gathering due to uncertainty in specific inspection area

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs and replaces civil structures due to various drivers described in Table 7 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Civil structures are installed as per approved procedures and standards available in the Underground and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 7: Drivers for Civil Structure Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. vehicle accident
System Service	• New assets to improve reliability • New assets to improve capacity constraints

While Hydro Ottawa tracks the installation dates for all structures, Hydro Ottawa has not historically tracked quantities of civil structures installed for a specific investment category or due to the driver that triggered the installation. Table 8 shows the historical installation of cable chambers encompassing all system investment drivers.

Table 8: Cable Chambers Historically Installed

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Cable Chambers Installed	122	127	115	145	144

6.1.1. System Access

Hydro Ottawa performs system access work which is driven by customers and third parties. These include:

Customer Connections

- New civil structure installed to support service equipment
- New civil structure installed to support distribution underground conductors to expand Hydro Ottawa's system

Relocated Assets

- Relocate civil structure to accommodate work (e.g. new developments, road expansions) and eliminate clearance concerns



Figure 5: Cable Chamber for a Padmounted Switch

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the civil structures. As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted by]a civil structure failure. Hydro Ottawa replaces civil structures each year in both a proactive and reactive manor based on feedback from Hydro Ottawa staff through visual inspections, the ACA health index results from detailed inspections and feedback from third parties citing concerns.



Figure 6: Degraded Cable Chamber Roof and Collar

Corrective Renewal
Civil structures which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual or through calculating the ACA health index score. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 10. Where applicable, the civil structure may be built to align with future plans such as adding an operable way for a future underground conductor connection.

Table 9: Civil Structures Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	*Critical Replacement (Imminent Risk)*
Collapsed member (wall, roof, collar)	Imminent collapse
Crack / gap permitting access to energized component	Sunken base impeding access/affecting asset management objectives
Health index of 0%	Insufficient health index (very poor / < 30%)

Planned Renewal
Civil structures which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Hydro Ottawa reviews civil structure's calculated ACA health index and underground switchgears in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's civil renewal program. Additionally, civil structures may be replaced in conjunction with planned work for other assets where efficiencies can be gained. Pads may be replaced upon the replacement of the supported equipment due to changes in material and construction standards.

Assets Damaged by Third Parties
Civil Structures which are damaged by third parties are replaced immediately after the area is made safe. Historically this damage has been due to motor vehicle accidents or construction equipment.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by civil structure work, but may require civil structures to be installed or replaced to accomplish the identified objectives. The drivers of these projects include:

Voltage Conversion

- Reduce Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements

- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades

- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Civil structures are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they require replacement. Additionally, the condition of the civil structures is reviewed to determine if replacement due to end-of-life is anticipated. Civil structures may be replaced before their end-of-life based on technical requirements or overall economic efficiencies.

6.2. Operations & Maintenance Plan

Civil structures Inspection

Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and a detailed inspection to capture ACA information on civil structures, specifically cable chambers and pads. Hydro Ottawa's employees perform passive visual inspections on civil structures regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found through work in the distribution system are reported by exception as per the intent of ESG0001 *Hydro Ottawa Electrical Distribution Safety Construction Verification Program in compliance with Ontario Regulation 22/04*, so the issue can be rectified.



Figure 7: Crews Performing Cable Chamber Inspection and Maintenance

Hydro Ottawa uses external contractors to perform detailed visual inspections on pads which are reported with the inspection report for the supported equipment. These inspections follow both the UIS0001 *Padmount/Kiosk Transformer Inspection* procedure and UIS0002 *Padmount Switchgear Inspection* procedure.

Hydro Ottawa uses internal crews to perform a detailed inspection on cable chambers following the working procedure UIS0004 *Underground Cable Chamber Inspection* procedure. During the inspection, the underground cables may also undergo infrared scanning. The results are used to manage Hydro Ottawa's underground cables and discussed in the respective AMP. This inspection information is used to calculate the overall condition of cable chambers by calculating a health index using the ACA described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the cable chamber's condition. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections can be used to determine the asset maintenance and renewal plans. In the instances asbestos is encountered, Hydro Ottawa has a number of documented procedures, including Hydro Ottawa document PRO-HEA-014, *Asbestos Management*

Program, WI-HEA-003 *Asbestos Cable Wrap Removal in Manholes*, WI-ENV-020 *Asbestos Transport and Storage*, and WI-HEA-004 *Asbestos Cable Wrap Removal Using Glove Bags*.

Cable Chamber Repairs
Hydro Ottawa performs reactive maintenance and repair to cable chambers when there are minor issues which don't classify the cable chamber as having reached its end-of-life (through the inspection process mentioned above). These activities aim to sustain the performance of civil structures, mitigate further deterioration and achieve their expected useful life. Typical activities include performing repairs on cable chamber's collars and lids to prevent further ingress of moisture that may accelerate the cable chamber's deterioration or remove tripping or traffic hazards.

6.3. Disposal Plan

Hydro Ottawa disposes of civil structures when they require replacement or are deemed no longer required. Hydro Ottawa uses external contractors to decommission the concrete and duct and dispose of it. Cables containing asbestos wrap, and any duct attached to said cables, are replaced based on health, safety, and environmental requirements as per PRO-HEA-014 *Asbestos Management* Program.

6.4. Contingency Planning

Hydro Ottawa does not directly procure civil structures as all civil structures are procured through outside services. However, Hydro Ottawa does interface with contractors and suppliers on standards and specifications to ensure that the proper material and specifications are met.



Figure 8: Manhole Cover, Example of Civil Structure

7. Future Demand

Hydro Ottawa actively manages both pads and cable chambers within the civil structure assets. Future pad installations will be driven by the inspection or installation of the supported equipment outlined in their respective AMP. Hydro Ottawa does not record the installation of cable chambers with respect to the various OEB drivers. Therefore, Hydro Ottawa expects to continue installing cable chambers in numbers aligned to the previous five-year average.



Figure 9: Degraded Cable Chamber Roof and Exposed Rebar

Based on the inspection results and as Hydro Ottawa expects to continue with the inspection program described in section 6.2, Hydro Ottawa requires an increase in cable chamber repairs and replacements. Beginning in 2021, Hydro Ottawa plans to increase the planned civil renewal program from roughly 6-8 cable chamber rebuilds per year to 17. In addition, for cable chambers the current 2-4 roof rebuilds will be increased to 12. Hydro Ottawa expects that once every cable chamber has undergone a detailed inspection, the level of corrective renewal will decrease and is expected to levelize. By replacing the amount of cable chambers described in Table 10 Hydro Ottawa mitigates the associated risks of a failure in order to meet the asset management objectives.

Table 10: Cable Chamber Installed / Replaced

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Installations	132	132	132	132	132	132	132

*Estimated Quantities

7.1. External Factors

7.1.1. Climate Change

Climate change has the ability to pose a significant threat to civil structures. While more resilient than overhead construction, freezing rain, snow and frost/thaw cycles have the capacity to degrade the civil structure's design limits and decrease their operating life. These events can lead to damaged assets and a reduction in Hydro Ottawa's levels of service. Specifically, freezing rain and snow lead to the use of de-icing salts which can accelerate the corrosion of steel and concrete used for civil structures. Freeze/thaw cycles also have the ability to degrade the ground surrounding civil structures as well as the structure itself.

Additionally, increased flooding and ingress of water into civil structures, specifically cable chambers can increase costs and the time required to complete work. This is due to the requirement to pump water out of a cable chamber prior to commencing work.

Furthermore, Hydro Ottawa is undertaking a distribution system climate vulnerability risk assessment and developing a *Climate Change Adaptation Plan* with the support of an external consultant. The results of this assessment will be used to assess and update Hydro Ottawa's various practices and standards.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. civil renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. underground) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Civil structure assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 40 years. The difference between the expected operating life and the financial useful life is that certain drivers require civil structures to be decommissioned or replaced before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's civil structures is approximately $107.5M[8] which represents 15.8% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy*, e.g. straight line depreciation. Therefore the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's civil structures is approximately $12.4M[8].

[8] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of civil structures in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0021 *Asset Management System Risk* will be used to address fundamental risks and opportunities with civil structures.

Hydro Ottawa will also assess the cost, benefits, and future mitigated risks of implementation of an inspection program for hand holes.

Hydro Ottawa also addresses issues with civil structures through the underground standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to underground assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

Hydro Ottawa has introduced requirements that cable chamber structures be constructed using "High Performance Concrete," as indicated in GSC0005 *Installation of Civil Works for Underground Distribution*. The "high performance concrete" allows for faster construction of manholes by reducing the curing time to three days or less, as opposed to seven, allowing for quicker backfilling. Furthermore, Hydro Ottawa's "high performance concrete" standard includes a waterproofing admixture that prevents water ingress into the concrete and allowed Hydro Ottawa to remove a requirement for an external weather proofing spray, further speeding up construction of cable chambers. Furthermore, "High Performance Concrete" has improved resistance to salt, improving durability and increasing service life.

Additionally, Hydro Ottawa updated its precast cable chamber and switching chamber standards to introduce the use of "polylok" pipe seal in the duct openings that allow the contractor to cut out the required duct opening with a knife instead of having to core drill each duct entry. The time and effort associated with core drilling is no longer required when using "polylok" pipe seal.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the *Asset Management System Communication Plan* IAP0021. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to civil structures achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way by being open to receiving information which could improve the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components within the regulatory submission. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A Diotte	NO: **IAP0009**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Underground Cables

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2018-01-11	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



Asset Management Plan – Underground Cables

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1. Introduction

Hydro Ottawa's underground cable assets are used to deliver electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management Plan*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - OIS0001 - *Overhead Distribution System Inspection*
Hydro Ottawa - OIS0003 - *Overhead Switch Inspection & Maintenance*
Hydro Ottawa - OIS0005 - *Overhead Line Inspection Method*
Hydro Ottawa - UIS0004 - *Underground Cable Chamber Inspection Procedure*
Hydro Ottawa - E&O intranet website - *Underground Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Underground Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Underground Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Underground Qualifications*
Hydro Ottawa - E&O intranet website - *Underground Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Underground Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Underground Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - TBC - *Estimated Age Analysis*[2]
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - *ISO55001*

[1] Most recent revisions of the referenced documents are to be used
[2] Document in progress

3. Asset Overview

This AMP covers Hydro Ottawa's underground cable assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. A system example of underground cable assets can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Underground cables(s) deliver value by enabling Hydro Ottawa to distribute electricity to customers in areas where it is impractical to install overhead distribution in accordance to Hydro Ottawa's *Conditions of Service*.

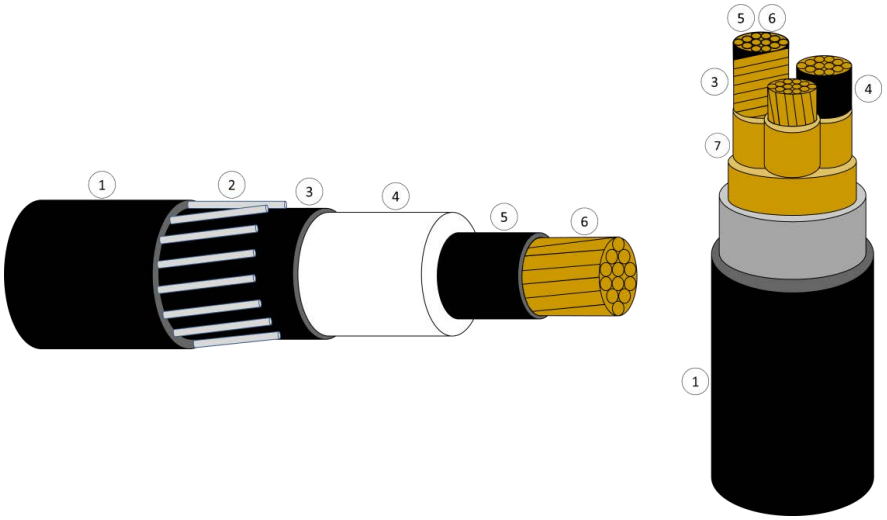


Figure 1: Underground Cable (Illustrative Purposes Only)

Table 1: Underground Cable (Functions)

Figure Number	Component	Function
1	Jacket	The cable jacket is an outer barrier that protects the cable from mechanical and moisture ingress.
2	Concentric Neutral	The concentric neutrals act as a shield and a neutral cable of carrying unbalance current.
3	Insulation Shield	The insulation shield ensures that unwanted electromagnetic interference is not transmitted along the cable and that excess energy is dissipated to ground properly.
4	Insulation	Insulation provides electrical and physical isolation between conductors and components of the cable.
5	Conductor Shield	The conductor shield protects individual conductors from electromagnetic interference.
6	Conductor	The conductor carries electrical current, and is a path for the flow of electricity from source to supply equipment, such as from transformers to customers.
7	Impregnated Paper Insulation	Impregnated paper insulation is an oil based type of insulation that provides electrical and physical isolation between conductors. This type of insulation is used for paper insulated lead covered cables.

Table 2: Class, Sub-class and Components of Underground Cable

Class	*Sub-Class*	*Components*
Underground Cable	Cross-linked Polyethylene/Tree-retardant Crosslinked Polyethylene (XLPE/TRXLPE)	Jacket, Concentric Neutral, Insulation Shield, Insulation, Conductor Shield, Conductor
	Ethylene Propylene Rubber (EPR)	Jacket, Concentric Neutral, Insulation Shield, Insulation, Conductor Shield, Conductor
	Paper Insulated Lead Covered (PILC)	Jacket, Lead-Alloy Sheath, Paper and Copper Tape Core Binder, Insulation Shield, Impregnated Paper Insulation, Conductor Shield, Conductor

Hydro Ottawa owns approximately 3,021km[3] of underground cable throughout the service territory. While the majority of underground cable is XLPE/TRXLPE cable, Hydro Ottawa also owns EPR and PILC cables to distribute electricity to customers. Figure 2 shows the demographics of the most common types of cables used by Hydro Ottawa Hydro Ottawa does have other underground cable types, including polyetherimide (PEI) cable and butyl rubber cable, as part of the distribution system. These types of underground cables are passively replaced with its equivalent as per the current standards.

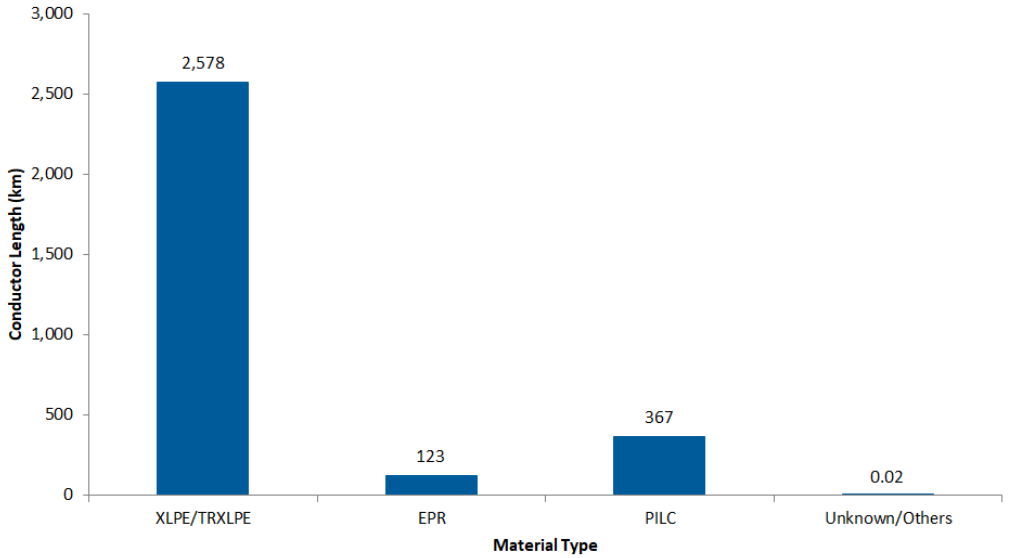


Figure 2: Length of Hydro Ottawa's Underground Cable Demographic by type

Currently, Hydro Ottawa has known and estimated purchase dates or installation dates stored in the Geographic Information System (GIS) for approximately 87% of its underground cable. The overall known age-demographics of underground cable for PILC and polymer (EPR, XLPE and TRXLPE) in the distribution system are shown in Figure 3 and Figure 4, respectively. The expected operating life of underground cable, where the probability of failure is approximately 2% or greater, is an effective age of 62 years for PILC, 45 years for EPR (this is treated like XLPE cable) and 45 years for XLPE/TRXLPE.

[3] Taken from 2018 QuickFacts

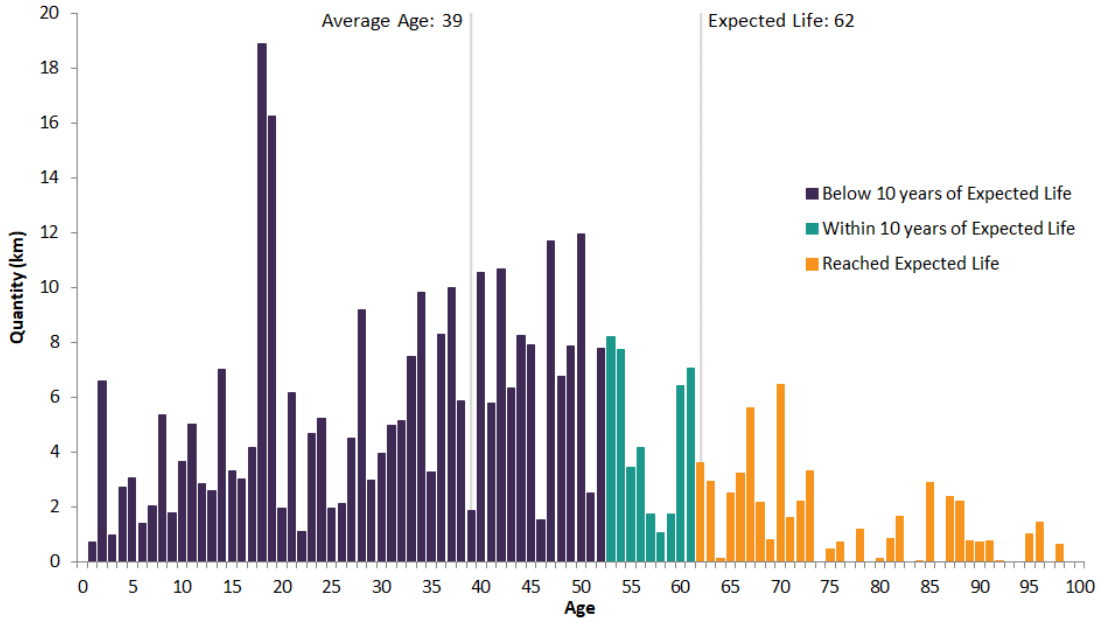


Figure 3: Hydro Ottawa's Underground PILC Cable Age Demographics[4]

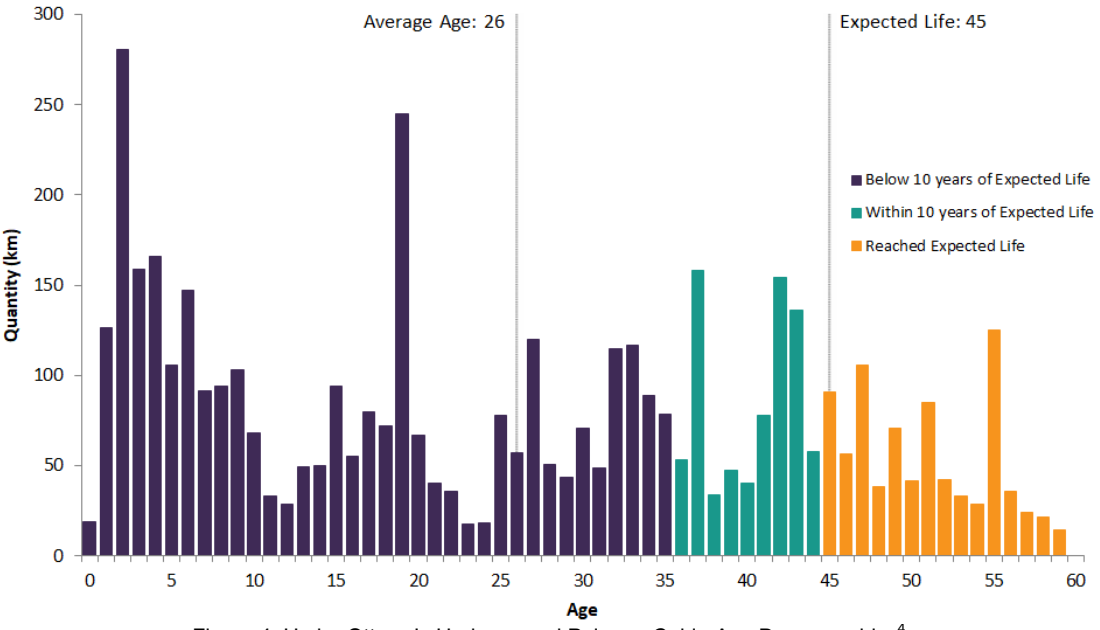


Figure 4: Hydro Ottawa's Underground Polymer Cable Age Demographics[4]

[4] Information as of December 2018

4. Asset Management Objectives

Underground cables require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact on service reliability through electrical interruptions which may be localized, affecting customers connected to that specific underground cable, or a larger outage affecting all downstream customers
- Achieve less-frequent electrical outages from external elements through the use of cable chambers and duct
- Achieve higher levels of customer satisfaction through less visually apparent electrical service.

Health, Safety & Environment Stewardship

- Impact employee safety due to asset failure in proximity of work areas
- Impact employee safety due to exposure to dangerous substances (lead and asbestos wrap)
- Impact environmental stewardship by releasing oil or lead through asset failure
- Impact environmental stewardship through cables that are insulated with asbestos wrap.

Asset Value

- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[5]
- Impact in asset lifecycle cost compared to overhead conductor due to a shorter expected life
- Impact asset lifecycle cost as the underground cable may not be rated for voltage conversion and therefore requires replacing versus bare overhead conductor
- Impact asset lifecycle cost relative to overhead installations due to higher general cost of material and installation

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually incorporates underground cable (and potentially other assets) in the same area[5]

In order to monitor and strive to improve the performance of underground cables, Hydro Ottawa reviews the Key Performance Indicators (KPIs), shown in Table 3, which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Distribution Underground Cable KPIs

KPI	*Target*
Underground cable (PILC) - SAIFI / 100 customers	3.29[6]
Underground cable (EPR & XLPE/TRXLPE) - SAIFI / 100 customers	3.5[6]
Underground cable (Other/Unknown) - SAIFI / 100 customers	1.47[6]
Underground cable attachment - SAIFI / 100 customers	1.14[6]

[5] Assumed based on resource and equipment requirements
[6] Based on a five (5) year average

KPI	*Target*
% of underground cable with health index information	100%
% of underground cable with very poor health index score	0%

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has implemented asset health indices for various assets to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections and the data collected is used to calculate underground cable's health index through the Asset Condition Assessment (ACA) described in section 6.2. Hydro Ottawa uses different approaches to collecting asset condition data depending on the insulating medium of the underground cable. Hydro Ottawa adapts its asset management approach to its underground cables based on the insulation medium; PILC cable is addressed differently from XLPE/TRXLPE and EPR primarily due to the differences in expected service life.

Hydro Ottawa performs non-destructive electronic testing on XLPE/TRXLPE underground cables to determine the condition of the cable's dielectric sheath. This data, combined with the cable's technical nameplate data and age, is used to determine the asset's health score. Hydro Ottawa has detailed inspection information on 80%[7] of its XLPE/TRXLPE underground cables which results in the health indexes shown in Table 4 below using the ACA methodology. This health index score is largely calculated using the age of the cable, as described in GEG0001 – *Asset Health Index Guideline.*

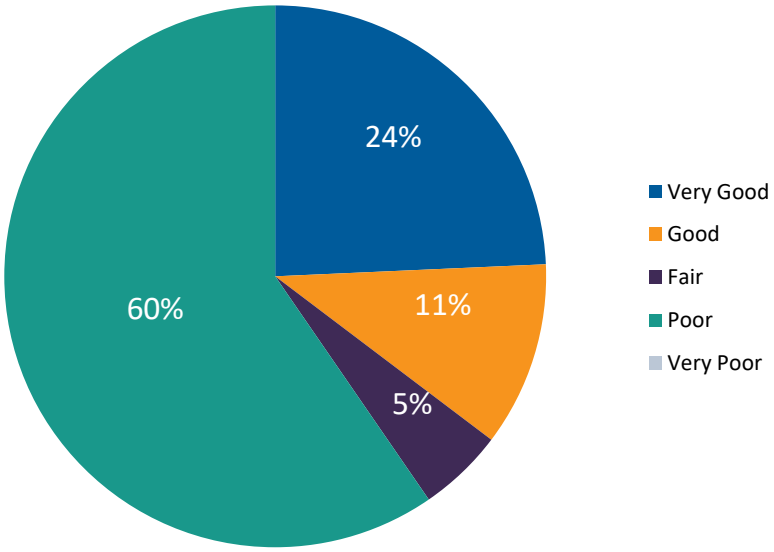


Figure 5: Hydro Ottawa XLPE/TRXLPE Underground Cable by Condition

Hydro Ottawa performs visual and thermographic inspection on PILC underground cables visible on poles (as part of the annual IR Scan performed on the overhead distribution system) and within Hydro Ottawa owned cable chambers (as part of the planned civil inspection program). Hydro Ottawa does not inspect the underground cable located in duct nor does it perform electronic testing on the cable as no economically viable technology is available to carry out the testing. PILC underground cable asset's health score is based primarily on the cable's technical nameplate data, limited inspection data collected and the cable's age. Hydro Ottawa has detailed inspection information on 83%[7] of its PILC underground cables which results in health indexes shown in Figure 6 below using the ACA methodology.

[7] Information as of August 2019

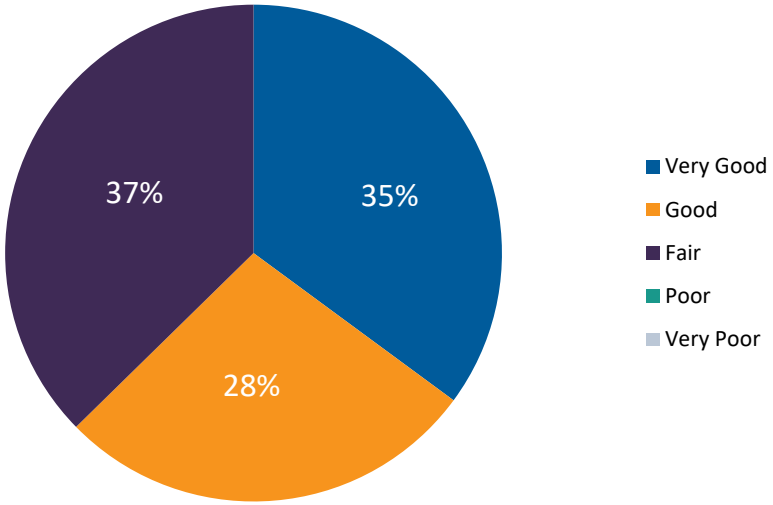


Figure 6: Hydro Ottawa PILC Underground Cable by Condition

Given the relatively young age of the EPR underground cable Hydro Ottawa uses in the distribution system, it is not discussed further within this document as it is essentially new equipment that poses low risk to the distribution system compared to other cable types.

Table 4: Underground Cable Condition KPIs

KPI	*Target*	*2017*
% of underground XLPE/TRXLPE cable with a health index score	**100%**	80%
% of underground PILC cable with a health index score	**100%**	83%
% of underground XLPE/TRXLPE cable with ACA compliant inspections with a very poor health index score	**0%**	0%
% of underground PILC cable with ACA compliant inspections with a very poor health index score	**0%**	0%

Hydro Ottawa currently does not meet the target of distribution underground cables with detailed inspections producing health index scores through ACAs shown in Table 4. Cables that do not have a health index or known installation date are invalid and if unable to assign an estimated age the cables will remain unknown until such a time that they are replaced or further investigation is completed. Hydro Ottawa is in the process of developing an *Estimated Age Analysis* that will be used to approximate the age of cables with unknown installation dates.

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). HOL's reliability performance is compared to the KPI target to drive continuous improvement with aim to reduce the number of outages caused by defective equipment year-over-year. Hydro Ottawa reviews reliability KPIs for both PILC and polymer underground cables. Historically Hydro Ottawa has not had complete accuracy recording faulted underground cables leading to unknown being recorded. This is expected to be minimal moving forward. Additionally, underground cable attachments and the outages their failures create are recorded. This equipment includes failed inserts, elbows and arrestors.

Table 5: Underground Cable Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Underground cable (PILC) - SAIFI / 100 customers	**3.29**	4.92	2.59	4.84	2.06	2.04
Underground cable (EPR & XLPE/TRXLPE) - SAIFI / 100 customers	**3.5**	1.4	6.33	0.59	1.91	7.26
Underground cable (Other/Unknown) - SAIFI / 100 customers	**1.47**	1.73	2.10	2.11	0.00	1.38
Underground cable attachment - SAIFI / 100 customers	**1.14**	4.52	0.27	0.51	0.34	0.05

Hydro Ottawa does not currently meets all the reliability target for outages due to defective underground cables and will continue to monitor reliability metrics for trends and improvements.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades underground cables due to various drivers described in Table 6 below corresponding with the Ontario Energy Board's (OEB) investment categories. Underground cables are installed as per approved procedures and standards available in the Underground and General sections of the Hydro Ottawa's Engineering & Operations intranet website. Hydro Ottawa investigated and trialed the injection of XLPE cable to improve the condition of the underground cable's insulation. This proved to not provide a large enough benefit to outweigh the cost of the maintenance activity and Hydro Ottawa no longer injects underground cable.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 6: Drivers for Underground Cables Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. construction dig in
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs system access work which is driven by customer and third-party requests. These may include:

Customer Connections

- Upgrades to existing underground cables to support service equipment
- Installation of new underground cables to support service equipment
- Installation of new underground cables to support the expansion of Hydro Ottawa's system

Underground Cables Relocated

- Relocation of underground cables to accommodate work (e.g. new developments, road expansions) and eliminate clearance concerns

Table 7 shows the historical underground cables issued to the field for various activities under system access.

Table 7: System Access - Underground Cables Installed / Replaced / Upgraded

Description	*Asset*	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection (km)	XLPE/TRXLPE	49.4	91.2	74.9	60.7	68.8
	PILC	0.5	1.8	0.5	0.5	0.0
	EPR	9.1	27.5	12.4	12.2	9.6
Assets Relocated (km)	XLPE/TRXLPE	9.1	3.1	4.8	7.4	1.7
	PILC	1.0	0.0	0.3	0.1	0.0
	EPR	3.3	3.8	5.4	0.8	0.0

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of the underground cable. As described in section 5, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through an underground cable failure. Hydro Ottawa replaces underground cables each year in both a proactive and reactive manner based on feedback from Hydro Ottawa staff through visual inspections, the ACA health index results from detailed inspections and feedback from third-parties citing concerns. Table 8 shows the historical underground cables issued to the field for various activities under System Renewal.

Table 8: System Renewal - Underground Cables Replaced / Upgraded

Description	*Asset*	*2014*	*2015*	*2016*	*2017*	*2018*
Corrective Renewal (km)	XLPE/TRXLPE	1.2	1.5	1.5	0.9	3.5
	PILC	1.1	0.9	2.1	1.5	0.5
	EPR	0.3	0.2	0.0	0.3	0.5
Planned Renewal (km)	XLPE/TRXLPE	23.4	12.1	36.6	13.8	23.1
	PILC	0.5	0.0	0.1	0.0	0.1
	EPR	1.0	0.1	0.3	1.8	2.3
Assets Damaged by Third Parties (km)	XLPE/TRXLPE	0.0	0.5	0.8	0.1	0.1
	PILC	0.2	0.2	0.2	0.1	0.1
	EPR	0.1	0.2	0.1	0.0	0.0

Corrective Renewal
Underground cables which pose an immediate or imminent risk to the asset management objectives are replaced under corrective renewal. These assets are identified immediately if the deficiency is visual or through calculating the ACA health index score, or due to frequent faults in the same cable segment. In addition to an asset condition that causes an outage, additional criteria which prompts corrective renewal are shown in Table 9. Where applicable, the underground cable may be upgraded to align with future plans to ensure the asset's full lifecycle is achieved.

Table 9: Underground Cables Corrective Renewal Criteria

Cable Type	*Emergency Replacement (Immediate Risk)*	*Critical Replacement (Imminent Risk)*
PILC	Cracked Pothead	Leaking Splice
	Dielectric Breakdown (Fault)	Swollen / Flat Sleeve
		Leaking Pothead
		Multiple Failures (Faults) in Same segment (AM Decision)
XLPE/TRXLPE	Unacceptable Testing (Q) Value	Overheating
	Failed Hi-Pot Test	Multiple Failures (Faults) in Same segment (AM Decision)
	Dielectric Breakdown (Fault)	Corroded Concentric Neutral
EPR	Dielectric Breakdown (Fault)	Overheating
	Failed Hi-Pot Test	Multiple Failures (Faults) in Same Length (AM Decision)
		Corroded Concentric Neutral

Planned Renewal
Underground cables which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their condition and associated risk. Underground cable's with a calculated ACA health index in a poor state (health index score of at least 30% but less than 50%) are planned for replacement in Hydro Ottawa's cable renewal program. Underground cables replaced under this program are generally grouped within a specific area to take advantage of efficiencies gained when replacing cable within similar proximity at the same time. Due to cost and specific training and knowledge, Hydro Ottawa is phasing PILC cable out of the system and replacing it with TRXLPE or EPR. PILC will continue to be used by exception primarily where space is an issue in a cable chamber to complete a transition splice to another cable type.

Underground Cable(s) Damaged
Underground cables which are damaged due to third-parties are replaced immediately after the area is made safe. Historically, this damage has been due to construction equipment digging into direct buried cable.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not driven by underground cable work, but often require underground cables to be installed, upgraded or replaced to accomplish the objectives. The drivers of these projects may include:

Voltage Conversion
- Reduces Hydro Ottawa's electrical system's energy losses and improve the energy capacity by increasing the supplying voltage. Additionally, reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements
- Improves Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades
- Improves Hydro Ottawa's System Accessibility for load and energy resource facility customers by removing capacity constraints

Underground cables are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they need to be replaced, upgraded or installed. Additionally, the age and condition of the underground cables are reviewed to determine if replacement due to end-of-life is anticipated. Underground cables may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 10 shows the historical underground cables issued to the field for various activities under System Service.

Table 10: System Service – Underground Cable Replaced / Upgraded / Installed

Description	*Asset*	*2014*	*2015*	*2016*	*2017*	*2018*
Voltage Conversion (km)	XLPE/TRXLPE	0.4	0.9	2.0	0.0	1.3
	PILC	0.0	0.0	0.0	0.0	0.0
	EPR	0.1	1.6	0.0	0.1	0.0
System Reliability (km)	XLPE/TRXLPE	0.4	1.8	4.5	11.7	0.0
	PILC	0.0	0.0	0.0	0.0	0.0
	EPR	0.0	0.1	0.2	0.0	0.0
System Capacity (km)	XLPE/TRXLPE	3.9	1.0	0.8	0.1	3.0
	PILC	0.0	0.0	0.0	0.0	0.0
	EPR	5.9	7.9	2.3	4.8	3.1

6.2. Operations & Maintenance Plan

Underground Cable Inspection
Hydro Ottawa proactively performs both a visual inspection, which reports deficiencies by exception, and detailed testing and inspection, to capture ACA information on XLPE/TRXLPE cables. Hydro Ottawa employees perform passive visual inspections on underground cables regularly as work takes place throughout the distribution system. Any issues or deficiencies that are found are reported by exception as per ESG0001 *Hydro Ottawa Electrical Distribution Safety Construction Verification Program in compliance with Ontario Regulation 22/04*, so that the issue can be rectified. Hydro Ottawa also uses external contractors to perform IR scanning following GNG0001 *Guidelines for Thermography* and GCS0015 *Thermographic Scanning of Power Lines and Distribution Apparatus*. Issues found from this inspection are reported to Hydro Ottawa and actioned for remedy.

Hydro Ottawa uses external contractors to perform a detailed inspection on XLPE/TRXLPE underground cables following the working procedure GCS0034 *Non-Destructive Testing for Detection of Water Trees in*

Underground Medium Voltage XLPE and TRXLPE Cable. This information, along with the details from the IR scanning, is used to calculate the overall condition of underground cables by calculating a health index score using the ACA method described in GEG0001 *Asset Health Index Guideline* which was developed in partnership with a third party industry expert. This provides a holistic assessment of the underground cable's condition. Results from inspections are stored in databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Underground Cable Repair
Hydro Ottawa performs reactive maintenance and repair to underground cables when there are minor issues which do not classify the underground cable as reaching its end-of-life (through the inspection process mentioned above). The maintenance must also be economic and justified. For PILC cable this includes repairing flat or swollen sleeves.

6.3. Disposal Plan

Hydro Ottawa disposes of distribution underground cables when they are removed from service due to various drivers. The metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. The oil in PILC cables is disposed of based on based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of underground cables which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 9.

This stock allows Hydro Ottawa to replace underground cables in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of approximately 9km of XLPE/TRXLPE, 900m of PILC and 2km of EPR underground cable of various sizes to be used during emergencies. The minimum quantity of underground cable is based on the asset's usage, the need to have replacement assets should an emergency occur, and the related manufacturing lead-time.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with manufacturers, contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of underground cables should an issue arise or more assets be required. Additionally, this includes using contractors beyond normal scopes of work to assist Hydro Ottawa crews in asset installation during emergencies.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in Section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual amounts of underground cable to be installed, replaced or upgraded are shown in Table 11.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B and cost sharing mechanisms (e.g. Public Service Works on Highways Act).

Table 11: Forecasted System Access – Underground Cable Installed / Replaced / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection (km)	XLPE/TRXLPE	69.0	69.0	69.0	69.0	69.0	69.0	69.0
	PILC	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	EPR	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Assets Relocated (km)	XLPE/TRXLPE	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	PILC	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	EPR	2.7	2.7	2.7	2.7	2.7	2.7	2.7

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by assets reaching end of life based on information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue with existing inspections and therefore forecasts the future demand of underground cables replaced due to corrective renewal to be in line with historical averages. Underground cables replaced due to damage by third-parties are forecasted based on historical averages.

Hydro Ottawa plans to proactively replace underground cables which result in a poor condition (health index score of at least 30% but less than 50%) through detailed inspections. Additionally, due to the risk posed by the number of underground cables in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined the amount of underground cables which require proactive replacement to mitigate the risk. This replacement strategy will prioritize underground cables based on their ACA results, as well as, level the future replacement of the growing and aging fleet of assets. This leveling allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual underground cable to be replaced or upgraded is shown in Table 12.

Table 12: Forecasted System Renewal – Underground Cable Replaced / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal (km)**	XLPE/TRXLPE	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	PILC	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	EPR	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Planned Renewal (km)	XLPE/TRXLPE	13.9	14.7	26.0	26.0	26.0	26.0	26.0
	PILC	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	EPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Estimated Quantities
**Based on 5 year historical data ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in Section 6.1.3. System improvement drivers may require underground cables to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for underground cable is shown in Table 13.

Table 13: Forecasted System Service – Underground Cables Replaced / Upgraded / Installed

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion (km)	XLPE/TRXLPE	1.9	1.9	0.0	0.5	0.0	0.0	0.0
	PILC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	EPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
System Reliability (km)	XLPE/TRXLPE	0.0	0.6	0.0	0.0	0.0	0.0	0.0
	PILC	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	EPR	0.3	0.0	0.0	7.2	0.0	0.0	0.0
System Capacity (km)	XLPE/TRXLPE	2.6	15.2	1.4	1.8	0.0	0.0	0.0
	PILC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	EPR	0.0	0.0	0.7	0.0	0.0	0.0	0.0

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact underground cable and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose significant threat to underground cables. One of the main impacts affecting underground cables due to climate change is rising temperatures. During the summer months where system electricity demand is already the highest compared to the rest of the year, increased heat and corresponding electrical responses, such as air conditioning, can put strain on system equipment including underground cables. An increasing occurrence of high-heat conditions, coupled with continued electrical demand growth can strain and limit supply capacity of these assets. Constant and timely system and asset monitoring and forecasting are required to ensure underground cables continue to operate safely and provide value through delivering the asset management objectives.

Furthermore, Hydro Ottawa is undertaking a distribution system climate vulnerability risk assessment and developing a *Climate Change Adaptation Plan* with an external consultant. The results of this assessment will be used to assess and update Hydro Ottawa's various practices and standards.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. cable renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. underground) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Underground cable assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 35 years and 60 years for polymer and PILC cable, respectively. The difference between the expected operating life and the financial useful life is that certain drivers require underground cables to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's underground cable is approximately $68.3M[8] for polymer cable and $18M[8] for PILC. Combined Hydro Ottawa's underground cable represents 12.6% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 Capitalization Policy (i.e. straight line depreciation). Therefore the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's underground cable is approximately $8.9M[8] and $1.5M[8] for polymer and PILC, respectively.

[8] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in section 4 used to measure performance of underground cables in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0021 – *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with underground cables

Hydro Ottawa also addresses issues with underground cable through the underground standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards with respect to underground assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions. One such example is the cable injection trial described in Section 6.2.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to underground cable achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0010**	REV: **2**
APPROVED:	L. Heuff		
REV. DATE:	2020-02-18		

Asset Management Plan
Station Batteries and Protection & Control Equipment

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2019-01-11	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Document Number	2020-02-18	ad/lh



Asset Management Plan – Station Batteries and Protection & Control Equipment

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1. Introduction

Hydro Ottawa's station batteries, protection and control equipment are used to support the delivery of electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - IAS0003 - *Strategic Asset Management System Plan*
Hydro Ottawa - IAP0012 - *Asset Management System Telecommunications*[2]
Hydro Ottawa - SIP0001 - *Station Inspection, Resolution, and Tracking Process*
Hydro Ottawa - SIP0006 - *Battery Maintenance Procedure*
Hydro Ottawa - WSS0008 - *Testing Relays*
Hydro Ottawa - GEG0001 - *Asset Health Index Guideline*
Hydro Ottawa - E&O intranet website - *Stations Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Stations Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Stations Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Stations Qualifications*
Hydro Ottawa - E&O intranet website - *Stations Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Stations Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Stations Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - *ISO55001*

[1] Most recent revisions of the referenced documents are to be used
[2] Document to be created

3. Asset Overview

This AMP covers Hydro Ottawa's station batteries and protection & control (P&C) assets. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. For the purposes of this AMP, control components are considered to be any hardwired signal or element that directly results in an action and is physically located at a station. Furthermore, station relays and batteries facilitate the control and support the monitoring and control of the distribution system, by facilitating remote annunciation, actuation and control of station assets, and automatically protecting the distribution system from electrical abnormalities.

For the purposes of this AMP, control and control components do not extend past relays, meaning that remote terminal units (RTUs) or any non-hardwired signal to the relay, such as fiber optic cable are not included in this AMP. These items are considered in IAP0012 – *Asset Management Plan Telecommunications*[3]. Figure 1 below illustrates the scope of this AMP.

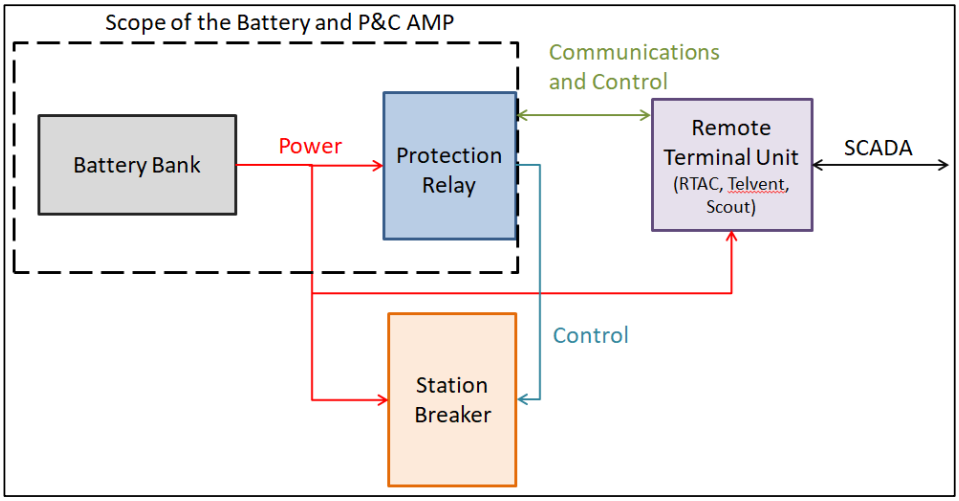


Figure 1: Scope of the Battery and P&C AMP

The system example of station batteries and P&C assets can be seen in Figure 2 and Figure 3, respectively. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1 and Table 2. Additionally, Table 3 below describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to station batteries and P&C includes the components below, which allow for the successful use of the asset. Instrument transformers are included in this AMP and critical to P&C, however, switchgear mounted instrument transformers are managed as part of the switchgear, and independent instrument transformers do not have a proactive inspection and maintenance program. Furthermore, control components included within P&C assets, such as hardwired cabling, interposing relays, and auxiliary contacts, are inherently included as part of the P&C asset class, but not independently managed. Table 3 illustrates the functional differences between electromechanical and microprocessor based relays, where the former is design in an analog manner whereby hardware is configured to achieve the desired settings, and the latter is a digital device that can be programmed for various functionality.

[3] Document to be created

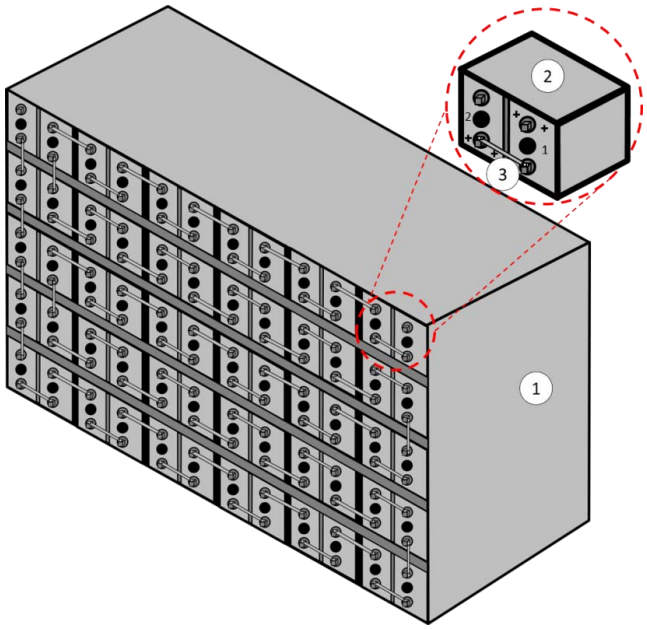


Figure 2: Station Battery (Illustrative Purposes Only)

Table 1: Station Battery Functions

Figure Number	Component	Function
1	Battery Bank	The battery bank serves as the power source for DC systems in substations, which include equipment such as protection relays and breaker coils. The bank supplies these systems and allows for their continued function when there is an electrical interruption.
2	Battery Cell	Battery cells independently hold charge and provide a specific voltage to be used in summation for the battery system. Individual battery cells can be replaced, eliminating the need for replacement of the whole battery bank in the event of a single battery failure.
3	Battery String Connection	Battery string connections allow for battery cells to be connected in series, creating a sum voltage of all connected cells, which determines the nominal rating of the battery bank.
Not Shown	Battery Charger	Battery chargers supply electricity to the battery cells to ensure they are able to support the connected DC systems. The charger also provides alarms in the case of abnormal conditions.



Figure 3: Protection & Control (P&C) Assets - Electro- Mechanical Relay (Left)[4] and Microprocessor Relay (Right)[5] (Illustrative Purposes Only)

Table 2: P&C Asset Functions

Figure Number	Component	Function
1	Time Dial	The time dial is used to vary the operating time of the relay. By changing the timing, various protection devices can coordinate with each other.
2	Instantaneous Trip Setting	The instantaneous trip setting is a value in amperes that when exceeded, will initiate an immediate trip output from the relay. The tripping of the relay is used to protect downstream equipment from electrical damage and maintain public and employee safety.
3	Tap Trip Setting	The tap trip setting is a value in amperes that when exceeded, will initiate a trip output from the relay following the specified curve associated with the relay and settings. The tripping of the relay is used to protect downstream equipment from electrical damage and maintain public and employee safety.
4	Induction Disc	The induction disc begins rotating when the amperage exceeds the trip setting and initiates the tripping of the relay and protective device. The time required for the disk to spin and trip the contact is set by the time dial.
5	Breaker Status	Breaker status lights provide feedback as to breaker position.
6	Display	The display shows settings and provides information on the relay's measurements, allowing for local control and troubleshooting of distribution system events and the minimization of outages.
7	Indicating Lights	Indicating lights provide various statuses related to the relay's status and operation.
8	USB & Communications Port	USB & communication ports are used for local connection and for local data transfer to and from relays.

Table 3: Class, Sub-class and Components of Station Batteries and P&C Equipment

Class	*Sub-Class*	*Components*
Station Batteries	Vented Lead Acid	Enclosure, Terminals (Posts), Connection Leads, Liquid Electrolyte, Positive Plates, Negative Plates, Flame Arrestor, Battery Charger
	Valve-Regulated Lead Acid (Gel Type)	Enclosure, Terminals (Posts), Connection Leads, Gelled Electrolyte, Positive Plates, Negative Plates, Flame Arrestor, Pressure Release Valve, Battery Charger

[4] Photo Courtesy of National Switchgear
[5] Photo Courtesy of Schweitzer Engineering Laboratories

Class	*Sub-Class*	*Components*
	Valve-Regulated Lead Acid (AGM Type)	Enclosure, Terminals (Posts), Connection Leads, Fibreglass Mats, Liquid Electrolyte, Positive Plates, Negative Plates, Flame Arrestor, Pressure Release Valve, Battery Charger
Protection Relays	Electromechanical	Enclosure, Dials, Overcurrent Sensing Mechanism, Wiring
	Electronic	Enclosure, Printed Circuit Board and Electrical Components, I/O Ports, Wiring
	Microprocessor	Enclosure, Microprocessor Chip, Motherboard and Electrical Components, I/O Ports, Software, Wiring
Instrument Transformers	Potential Transformer	Enclosure, Core, Windings, Insulating Medium, Bushings
	Current Transformer	Enclosure, Core, Winding, Insulating Oil

3.1. Battery Demographics

Hydro Ottawa owns 63[6] station battery units located at Hydro Ottawa owned and co-owned substations throughout the service territory. There are two main types of batteries installed in Hydro Ottawa's substations, valve-regulated lead acid (VRLA), better known as sealed batteries, and vented lead acid (VLA), or flooded batteries. Figure 4 below shows the station battery type demographics installed throughout Hydro Ottawa's service territory.

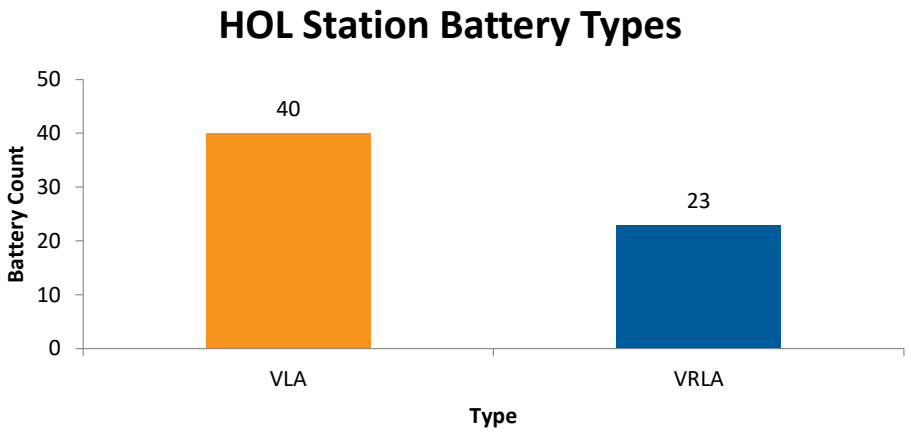


Figure 4: Count of Hydro Ottawa's Station Batteries by Sub-Class[7]

Currently, Hydro Ottawa has installation dates for 100%[7] of its station batteries. The overall known age demographics of batteries in Hydro Ottawa's stations are shown in Figure 5 below. The expected operating life of VRLA batteries is 15 years, while VLA batteries have an expected operating life of about 25 years. The expected life shown in Figure 5 is the average of the expected operating life of VRLA and VLA batteries, as it includes both types of batteries.

[6] Information as of Dec 2018

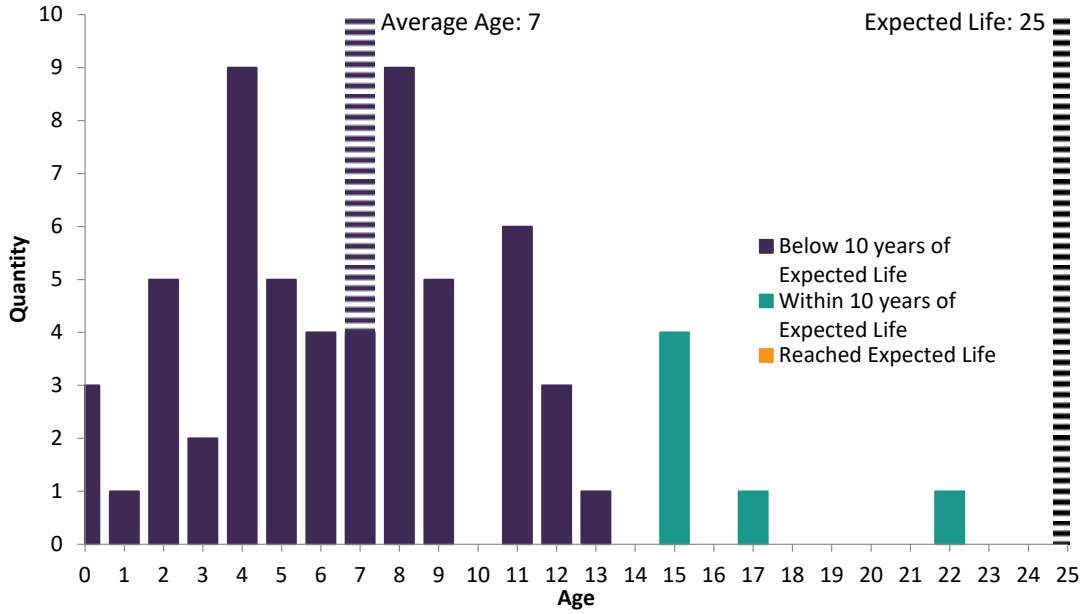


Figure 5: Hydro Ottawa's Station Batteries Age Demographics[7]

3.2. P&C Equipment Demographics

Hydro Ottawa owns 1,006[8] station protective relay sets located at Hydro Ottawa owned and co-owned substations throughout the service territory. There are three main types of relays installed in Hydro Ottawa's substations, electromechanical, electronic and microprocessor relays. Electromechanical relays have historically been used to provide feeder-level protection in old substations. They are set with mechanical dials, and operated by electromagnets and springs to close mechanical contacts. Electronic relays are more modern, and make use of analog electronic circuits to simulate the function of electromechanical replays, without the moving mechanical parts. Microprocessor relays are the most modern relay type, and use digital signals and microprocessors to perform calculations and send control signals.

Figure 6 below shows the station relay type demographics throughout Hydro Ottawa's service territory.

[7] Information as of Dec 2018
[8] Information as of April 2018

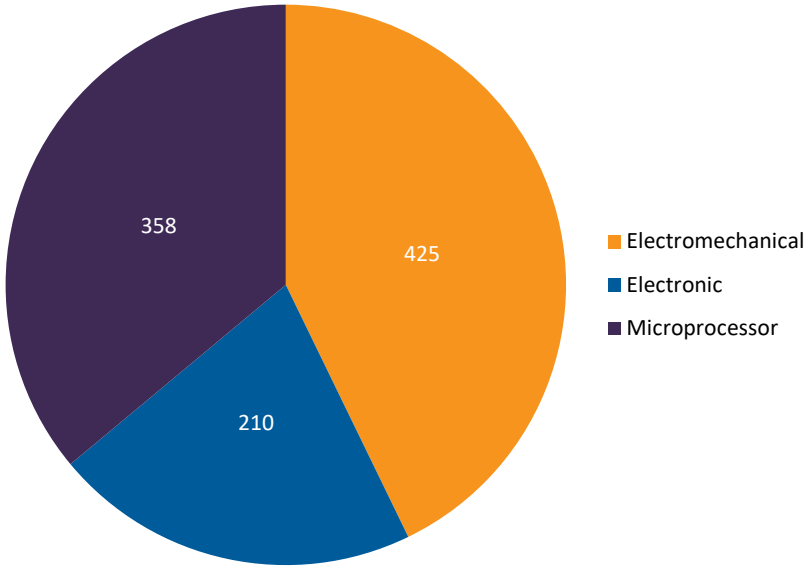


Figure 6: Count of sets of Hydro Ottawa's Protective Relays by Sub-Class[8]

Currently, Hydro Ottawa has installation dates for 100%[8] of its station relays. The overall known age demographics of relays in Hydro Ottawa's stations are shown in Figure 7 and Figure 8 and Figure 9 below. The expected operating life of relays is 40 years for electromechanical, 25 years for electronic, and 15 years for microprocessor (note that though the expected life of 15 years for microprocessor relays is plotted, all relays are plotted with respect to their expected average age per relay type).

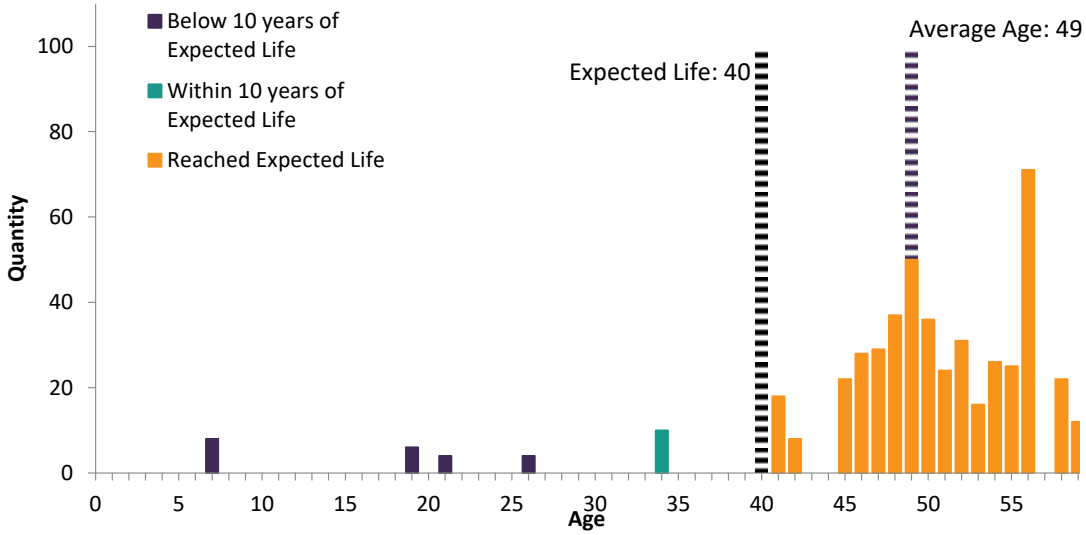


Figure 7: Hydro Ottawa's Station Electromechanical Relay Age Demographics

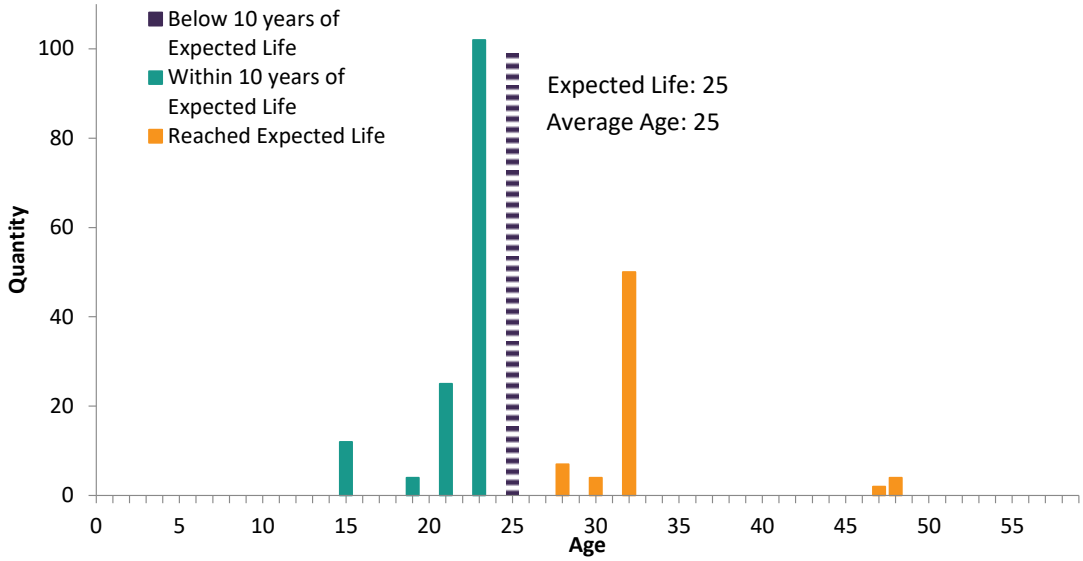


Figure 8: Hydro Ottawa's Station Electronic Relay Age Demographics

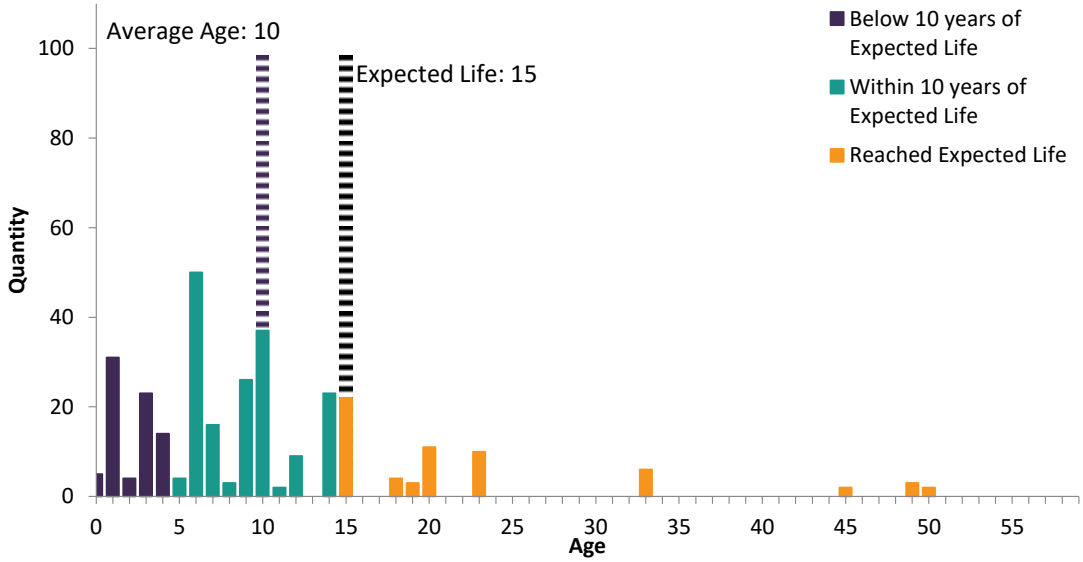


Figure 9: Hydro Ottawa's Station Microprocessor Relay Age Demographics

4. Asset Management Objectives

Station batteries and P&C systems require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Achieve reduction of affected customers due to an electrical abnormal condition by isolating the system
- Achieve reduction in electrical outage duration through protective device selectivity
- Impact system reliability through a failed relay causing the upstream relay to operate affecting a larger number of customers in the event of a system electrical outage or the miss-operation of the protected equipment (e.g. breaker)
- Achieve required operation of supported equipment through backup power supply
- Impact system operations ability to monitor and control breakers as enabled by the relays and locally installed control hardware

Health, Safety & Environment Stewardship

- Impact employee and public safety due to protective relays not operating as intended
- Achieve employee safety and work protection through the creation of Hold Offs and allowing workers to isolate the system before performing any labour on station equipment
- Impact employee safety due to battery failures which can result in acid leaks or combustible hydrogen gas buildup

Asset Value

- Impact asset lifecycle cost from equipment (distribution and station) and property damage due to protective relays not operating as intended
- Impact in asset lifecycle cost as an emergency replacement is more costly than planned replacement[9]

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less efficient than planned replacement which usually includes the replacement of multiple assets at the same time[9]
- Impact effectiveness of operating due to parts and software obsolescence
- Impact on operation and maintenance efficiency as newer technologies replace obsolete technologies, while obsolete technologies exist within the system

In order to monitor and strive to improve the performance of station batteries and P&C equipment, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 4 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 4: Station Batteries and P&C Equipment KPIs

KPI	*Target*
% of station batteries and relays with inspection information	100%
% of station relays with obsolete software	0%
Station relay - SAIFI / 100 customers	0.5[10]

[9] Assumed based on resource and equipment requirements
[10] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa completes testing and inspections to inform replacement and repair decisions. Hydro Ottawa performs both visual (passive overview to report observed deficiencies) and detailed (active review to capture specific health information) inspections on its station batteries and testing on station relays. Station battery and relay information is presently available on a per station basis, and Hydro Ottawa is in the process of updating database querying capabilities with implementation to be completed by the end of the first quarter of 2019. Station batteries and relays currently do not have defined criteria to establish a health index. Hydro Ottawa plans to continue with existing inspection practices for all station batteries and relays and an overview of station battery and relays with detailed inspection information is provided in Table 5.

Table 5: Station Battery and Relay Condition KPIs

KPI	Target	2017
% of station batteries with detailed inspection information	**100%**	100%
% of station relays with detailed testing information	**100%**	54%

The effective support and management of electronic and microprocessor relays are based on the ongoing support of the underlying relay software and computer operating system compatibility. Due to innovation and improvements, relay vendors may discontinue support of older relay units. This reduces Hydro Ottawa's ability to continue to maintain the equipment thereby impacting the reliability of the equipment to protect the distribution system. An overview of relays with obsolete software is presented in Table 7. Obsolete software is planned to be removed from the system by 2019 as part of regular testing and maintenance as described in Section 6.2.

Table 6: Station Relay with Obsolete Software KPIs

KPI	Target	2017
% of station relays with obsolescent software	**0%**	2.5%

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement to reduce the number of outages year-over-year.

Table 7: Station Relay Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Station relay - SAIFI / 100 customers	**0.38**	0.00	1.63	0.24	0.00	0.00

Hydro Ottawa currently meets the reliability target for outages due to defective station relays and will continue to monitor reliability metrics for trends and improvements.

Station relays may also fail and not cause and outage. This is also true for station batteries as they support the operation of equipment as a backup power supply. Typically, failed equipment is identified by means of monitoring through Hydro Ottawa's Supervisory Control and Data Acquisition (SCADA) and can be isolated and replaced before outages occur. Further information on Hydro Ottawa's SCADA can be found in IAP0012 – *Asset Management Plan Telecommunications.*

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs and replaces station batteries and P&C equipment due to various drivers described in Table 8 below corresponding with the Ontario Energy Board's (OEB) investment categories. Station batteries and P&C equipment are installed as per approved procedures and standards available in the Station and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While generally there is a single driver initiating a project, the affected assets and associated assets within a station are reviewed to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 8: Drivers for Station Battery and P&C Installation / Replacement

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection
System Renewal	• Assets replaced due to end-of-life and obsolescence • Assets replaced due to economic benefits or other strategic objectives
System Service	• New or upgraded assets to improve reliability, control and operability • New or upgraded assets to alleviate capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. This is generally not expected to drive station battery work. However, if a station is expanded for customer capacity, new breakers, and therefore the associated relays may be added, or a station's general control equipment is upgraded, which could mean new battery capacity may be required even though the batteries are not the primary driver for System Access.

Station relays installed, replaced or upgraded under System Access may include:

Customer Connections

- New station relay(s) installed to support Energy Resource Facilities (ERF)

Table 9 shows the historical station relays issued to the field for various activities under System Access.

Table 9: System Access – Station Batteries and Relays Installed / Replaced / Upgraded

Description	*Asset*	*2014*	*2015*	*2016*	*2017*	2018
Customer Connection	Battery	0	0	0	0	0
	Relay	1	0	2	7	0

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by the condition of station batteries and P&C equipment. As described in section 0, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a station battery or P&C equipment failure. Hydro Ottawa replaces station batteries and P&C equipment each year based on feedback from Hydro Ottawa staff, through visual inspection and testing results. Table 10 shows the historical station batteries and relays, based on manufacture date, issued to the field for various activities under System Renewal.

Table 10: System Renewal – Station Batteries and Relays Replaced / Upgraded

Description	Asset	2014	2015	2016	2017	2018
Corrective Renewal	Battery	4	1	0	0	7
	Relay	0	1	4	0	0
Planned Renewal	Battery	5	1	4	1	0
	Relay	0	0	0	0	0

Corrective Renewal
Station batteries and P&C equipment which pose an immediate or imminent risk to the asset management objectives are replaced under corrective renewal. This equipment is identified either during monthly station inspections, or through detailed inspection and testing. The criteria used to determine if a battery or P&C equipment should undergo corrective renewal are listed in Table 11 and Table 12, respectively.

Table 11: Station Battery Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	Critical Replacement (Imminent Risk)
Battery charger failure	Battery charger overheating
Multiple battery cells fail testing	Single cell fails testing
Leaking batteries	Irreplaceable component fails

Table 12: Station P&C Equipment Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	Critical Replacement (Imminent Risk)
Relay failed	SCADA communications failed
Power supply failed	
Software error	
Input/Output board failed	

Planned Renewal
Station batteries and P&C equipment which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on their age and information from testing and inspections. Planned renewal also reviews the condition of major substation equipment (e.g. transformers and switchgear) to identify opportunities to replace equipment at the same time to drive resource efficiencies.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by station battery or P&C equipment work, but may require the equipment to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects may include:

Reliability Improvements
- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions
- Improve Hydro Ottawa's level of service by updating P&C technology and settings as the distribution hardware and capacity evolves

Capacity Upgrades
- Upgrade substation equipment to accommodate additional loading requirements

Station batteries and P&C equipment may be replaced before their end-of-life based on technical requirements or overall economic efficiencies to accommodate System Service projects. Table 13 shows the historical station batteries and relays issued to the field under System Service.

Table 13: System Service – Station Batteries and Relays Replaced / Upgraded / Installed

Description	Asset	2014	2015	2016	2017	2018
System Reliability	Battery	0	0	0	0	0
	Relay	20	10	34	12	0
System Capacity	Battery	0	0	1	0	0
	Relay	0	0	0	0	0

6.2. Operations & Maintenance Plan

Station Battery Inspection and Testing
Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and detailed testing and inspection to capture condition data on the station batteries. Hydro Ottawa's employees perform visual inspections on station batteries on a monthly basis. Visual condition and deficiencies are reported as described in the working procedure SIP0001 *Station Inspection, Resolution, and Tracking Process* so that they may be rectified.

Hydro Ottawa also completes detailed inspection and testing on station batteries following the operating procedure SIP0006 *Battery Maintenance Procedure*. This procedure also details the time frames for the various tests to be performed. The testing and inspections completed on station batteries include:

- Thermographic surveys;
- Checking oil levels; and
- Checking electrolyte levels;

These tests and inspections provide a holistic assessment of the station battery's condition. Results from inspections are stored in Hydro Ottawa's station maintenance software. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Station P&C Equipment Inspection and Testing
Hydro Ottawa proactively performs both visual inspections and detailed testing and inspection to ensure the correct operation of station P&C equipment, namely protective relays. Hydro Ottawa's employees perform visual inspections on station P&C equipment on a monthly basis. Visual condition and deficiencies are reported as described in the working procedure SIP0001 *Station Inspection, Resolution, and Tracking Process* so that they may be rectified.

Hydro Ottawa also completes detailed inspection and testing on station relays following the standard work method WSS0008 *Testing Relays* and includes testing all applicable logic and trip functions.

The inspection and testing ensures that Hydro Ottawa's P&C equipment operates as intended. Results from inspection and testing are stored in Hydro Ottawa's station maintenance software. The information provided through inspections is used to determine the asset maintenance and renewal plans.

Station Battery and P&C Equipment Repair
Hydro Ottawa does not repair station batteries since batteries typically fail in a way that makes repair impractical. For example, a common failure mode of sealed gel-type batteries is the loss of electrolyte volume due to overcharging. To top up the electrolyte, the sealed battery must be physically opened, which comes with a high risk of further damaging the battery.

Hydro Ottawa performs maintenance and repair to station electromechanical relays as there are physical components which can be repaired or replaced. Repairs on electronic relays and microprocessor relays may be performed when there are minor issues that can be economically resolved and therefore do not classify the station relay as reaching its end-of-life (through the inspection process mentioned above). In certain cases, it is practical to send a microprocessor relay back to the manufacturer for troubleshooting and repairs. For example, Hydro Ottawa has previously sent back some microprocessor relays to be repaired due to lack of spares at the time.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses station equipment depending on their condition when they are removed from service. Due to the health, safety and environmental implications of battery disposal, disposal of station batteries is handled by external contractors based on environmental requirements as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*. Station P&C equipment is disposed of through equipment recycling, where possible, allowing Hydro Ottawa to recover scrap value. Additionally, parts may be kept, if in working condition, as spares to repair other equipment still in service.

6.4. Contingency Planning

6.4.1. Batteries

Hydro Ottawa does not maintain a stock of spare station batteries. This is due to the limited operational life of batteries and that they self-discharge when kept in storage. When a battery cell fails, it is taken out of the bank to ensure it doesn't damage the other cells and is replaced as soon as possible. Furthermore, battery banks are designed such that if cells are removed or short circuited, the bank can still operate and without alarm as long as the battery bank supplies over 117 VDC (at 2.1 V per cell, up to 6 cells can fail due to short circuit).

Hydro Ottawa maintains a portable battery bank that can be brought and connected at a station in the case of battery failure.

Furthermore, when battery banks are active, and if the station in question has the appropriate connection configuration, generators are used to support the DC system and charge batteries during the loss of the station service. Similarly, when there is an outage, batteries are turned off to preserve charge, so that when the station is ready to be reenergized, the batteries have available charge to return to service and operate as required.

6.4.2. P&C Equipment

Hydro Ottawa maintains spare relays and parts for the most common P&C devices deployed in the field. When spare P&C equipment is required, equipment can be temporarily removed and used from other parts of the system if required. Hydro Ottawa also maintains partnerships with P&C equipment suppliers to allow for shortened lead times when additional P&C equipment requires procurement in an emergency situation. Additionally, where Hydro Ottawa's protection devices are installed in redundancy, new components can be procured while upholding the asset management objectives.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category.

It is uncommon that Hydro Ottawa replaces batteries due to drivers under System Access. System Access work requested by third parties for P&C installation or upgrade is typically driven by the connection of large ERFs requiring protection communications into Hydro Ottawa's system. Table 14 shows the forecasted demand for station relays due to ERF connections.

Table 14: Forecasted System Access – Station Batteries and Relays Installed / Replaced / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	Battery	0	0	0	0	0	0	0
	Relay	4	2	2	2	2	2	2

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by asset failure and information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue the constant monitoring, inspections and maintenance of station batteries and P&C equipment. The forecast for corrective replacement of failed station batteries and relays are based on historical averages.

Hydro Ottawa plans to proactively replace station batteries based on their age and condition with respect to the operating life for VLRA and VLA batteries. Additionally, due to requiring less maintenance, Hydro Ottawa plans to install only VLRA batteries moving forward. Hydro Ottawa is also initiating a planned program for relay replacement to mitigate future risk of failure based on age with respect to the operating life for the relay as well as the availability of parts and software obsolescence. Table 15 shows the forecasted replacement of station batteries and relays under corrective and planned renewal.

Table 15: Forecasted System Renewal – Station Batteries and Relays Replaced

Description	Asset	2019	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal	Battery	1	0	0	0	0	0	0
	Relay	1	1	1	1	1	1	1
Planned Renewal	Battery	0	0	2.6	2.6	2.6	2.6	2.6
	Relay	24	24	12	12	0	0	0

*Estimated Quantities

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require station batteries and P&C equipment to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by prioritized projects which require work to be completed on these or the associated (e.g. switchgear) assets. The forecasted annual demand for station batteries and relays is shown in Table 16.

Table 16: Forecasted System Service – Station Batteries and Relays Replaced / Installed / Upgraded

Description	Asset	2019*	2020*	2021*	2022*	2023*	2024*	2025*
System Capacity	Battery	1	2	0	1	0	0	0
	Relay	14	14	14	14	14	14	14

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact station batteries and P&C equipment and their ability to continue to deliver value in support of the asset management objectives.

7.4.1. Climate Change

Due to the temperature controlled rooms and enclosures surrounding station batteries and P&C equipment, Hydro Ottawa does not expect adverse impacts climate change. However, the criticality of these assets increases with the increase in the number of weather related outages in the distribution system.

Furthermore, Hydro Ottawa is undertaking a distribution system climate vulnerability risk assessment and developing a Climate Change Adaptation Plan with the support of an external consultant. The results of this assessment will be used to assess and update Hydro Ottawa's various practices and standards.

7.4.2. Smart Grid Adaptations

As the concept of Smart Grid and the practicality of new technologies arise, P&C and battery equipment used by Hydro Ottawa will adapt and enable the potential for new, innovation solutions and business drivers.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. station battery and P&C renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. stations) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Station batteries and P&C assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity over their expected financial useful life of 25 years. The difference between the expected operating life and the financial useful life is that all station equipment with the exception of station transformers and switchgear are capitalized together, and a single financial useful life is required to represent all equipment. Projects to replace station assets can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's station batteries and P&C assets is not discretely tracked within Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS), but is tracked in a larger pool of supporting station assets (excluding transformer and switchgear) which totals approximately $44.2M[11] and represents 6.5% of total distribution assets. Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy* (i.e. straight line depreciation); therefore, the assets depreciate annually over their expected financial useful life. The existing accumulated depreciation of Hydro Ottawa's station batteries and P&C assets is approximately $10.3M[11].

[11] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in Section 4 used to measure performance of station batteries and P&C equipment in achieving the asset management objectives. The performance of these assets is described in Section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with station batteries and P&C equipment.

Hydro Ottawa also addresses issues with station batteries and P&C assets through the stations standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards with respect to station assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

Furthermore, Hydro Ottawa is presently in the process of developing a health index for independently mounted instrument transformers (namely potential transformers and current transformers that do not have a proactive inspection and maintenance program as part of other equipment, such as switchgear).

Hydro Ottawa is in the process of updating records and data on protective relaying and which relays which have proactive inspection and maintenance programs.

Various topics within relay testing and maintenance are under investigation by Hydro Ottawa, for potential implementation namely:

- remote relay programming via SCADA;
- storing multiple relay settings groups within relays; and
- Automated testing of relays with an increased testing frequency.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to station batteries and P&C equipment achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
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APPROVED:	L. Heuff		
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Asset Management Plan
Vault Transformer

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2018-01-11	cm/gp/jm
1	General Content Revision	2020-01-06	ad/lh
2	Updated Policy Number Document	2020-02-18	ad/lh



Asset Management Plan – Vault Transformers

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1. Introduction

Hydro Ottawa's vault transformers are used to modify voltage levels to supply electricity to customers throughout the service territory safely and reliably. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes current condition and performance in order to identify gaps for continuous improvement and establish remedial actions. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - *Distribution System Plan*
Hydro Ottawa - POL-ED-IAS0001-01 - *Asset Management Policy*
Hydro Ottawa - IAS0002 - *Asset Management System Manual*
Hydro Ottawa - VIS0001 - *Electrical Equipment Vault Inspection and Maintenance*
Hydro Ottawa - GCS0015 - *Thermographic Scanning of Power Lines and Distribution Apparatus*
Hydro Ottawa - WTS0002 - *Testing Used Distribution Transformers*
Hydro Ottawa - E&O intranet website - *Underground Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *General Policies, Guidelines & Design Considerations*
Hydro Ottawa - E&O intranet website - *Underground Calculations & Tables*
Hydro Ottawa - E&O intranet website - *Underground Materials*
Hydro Ottawa - E&O intranet website - *General Materials*
Hydro Ottawa - E&O intranet website - *Underground Qualifications*
Hydro Ottawa - E&O intranet website - *Underground Construction and Bill of Materials*
Hydro Ottawa - E&O intranet website - *Underground Inspection & Maintenance*
Hydro Ottawa - E&O intranet website - *Underground Archives*
Hydro Ottawa - E&O intranet website - *Department Processes*
Hydro Ottawa - E&O intranet website - *Standard Work Methods*
Hydro Ottawa - POL-Fi-013 - *Capitalization Policy*
Hydro Ottawa - WI-ENV-006 - *Hazardous and Liquid Waste Disposal*
Hydro Ottawa - WI-ENV-023 - *Oil and Oil Filled Equipment Transportation*
Ontario Energy Board - *Distribution System Code*
British Standards Institution - ISO55001
Government of Canada - SOR/2008-273 - *PCB Regulations*
METSCO Energy Solutions - *Asset Health & Risk Assessment Method R1*

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's vault transformer assets, and for the purposes of this classification means that the transformers in question are located inside buildings; note that vault transformer refers to the collective types of vault transformers in common use, including oil-filled and dry-core. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. The system example of vault transformers can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Additionally, Table 2 describes the hierarchy between asset class, sub-class and components within Hydro Ottawa's distribution system. Unless specified, referring to vault transformers includes the components below which allow for the successful use of the asset.

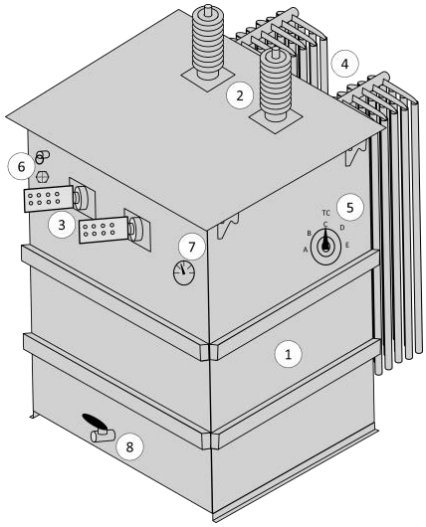


Figure 1: Oil Filled Vault Transformer (Illustrative Purposes Only)

Table 1: Vault Transformer Functions

Figure Number	Component	Function
1	Enclosure	Vault transformer enclosures maintain isolation of the medium and low voltage equipment from environment while providing a degree of personnel protection from the energized internal components. Additionally, the enclosure contains the insulating oil.
2	Primary Bushing	Primary bushings support an insulated flow of current from the connecting primary conductor to the internal transformer connections through the grounded enclosure.
3	Secondary Bushings	Secondary bushings support an insulated flow of current from the inside connections through the grounded enclosure to the secondary conductor.
4	Cooling Radiators	Cooling radiators provide convection cooling for the transformer allowing for the efficient dissipation of cool air across the transformer to prevent overheating.
5	Temperature Gauge	Temperature gauge provide a measurement of the oil temperature of a vault transformer and can be used as an indication of vault transformer operating condition.
6	Pressure Relief Device	The pressure relief device is used to avoid pressure buildup inside the transformers, and acts as an exit point for oil if the internal pressure exceeds permitted safe level.
7	Liquid Level Gauge	The liquid level gauge provides a level measurement of oil within the transformer tank to ensure the adequate amount of oil exists to cool and insulate the transformer.
8	Drain	The drain allows the transformer oil to be removed from the tank for maintenance or in a proactive or reactive manner for testing.

Figure Number	Component	Function
Not Shown	Tap Changer	The tap changer is used to regulate the voltage of the distribution vault transformer by changing the transformer's winding ratio. The tap changer can rotate up or down to either increase or decrease the ratio. This ensures that the voltage supplied by transformer is constant, even in cases where the incoming voltage is too high or too low. This results in the distribution of high-quality power.
Not Shown	Ground Connection	The ground connection allows for transformer connection to ground electrode which; prevents voltage on transformer enclosure, provides an effective ground-fault current path which is essential for the operation of the overcurrent protection systems, and provides reference for customer service voltage.
Not Shown	Core, Windings, insulating Oil	The transformer's core, primary and secondary windings and oil insulation are sealed within the transformer's enclosure. These elements work together to transformer the electrical power, stepping down from a distribution voltage to customer supply voltage using an electromagnetic circuit.

Table 2: Class, Sub-class and Components of Vault Transformers

Class	*Sub-Class*	*Components Belonging to or Supporting the Sub-Class*
Vault Transformer	Vault	Enclosure, Core, Windings, Bushings, Arrestors, Paper Insulation, Insulating Oil, Tap Changer and Pressure Relief Valve

Hydro Ottawa owns 3,652 vault transformers[2] throughout the service territory. Vault transformers are tracked separately to overhead and underground transformers, despite similarities in some of the equipment employed, due to the indoor operating environment. In addition to oil insulated vault transformers, Hydro Ottawa also uses dry-core step transformers in vaults for secondary to secondary voltage transformation. Vaults transformers are typically required in urban applications where adequate space is not available for padmounted equipment. Currently, Hydro Ottawa has known or estimated installation dates[3] stored in the Geographic Information System (GIS) for approximately 98%[2] of its vault transformers. The overall known age demographics of vault transformers in the distribution system are shown in Figure 2 below. The expected operating life of vault transformers, where the probability of failure is approximately 2% or greater, is an effective age of 53 years. Vault transformer effective age is assumed to be the same as padmounted transformers.

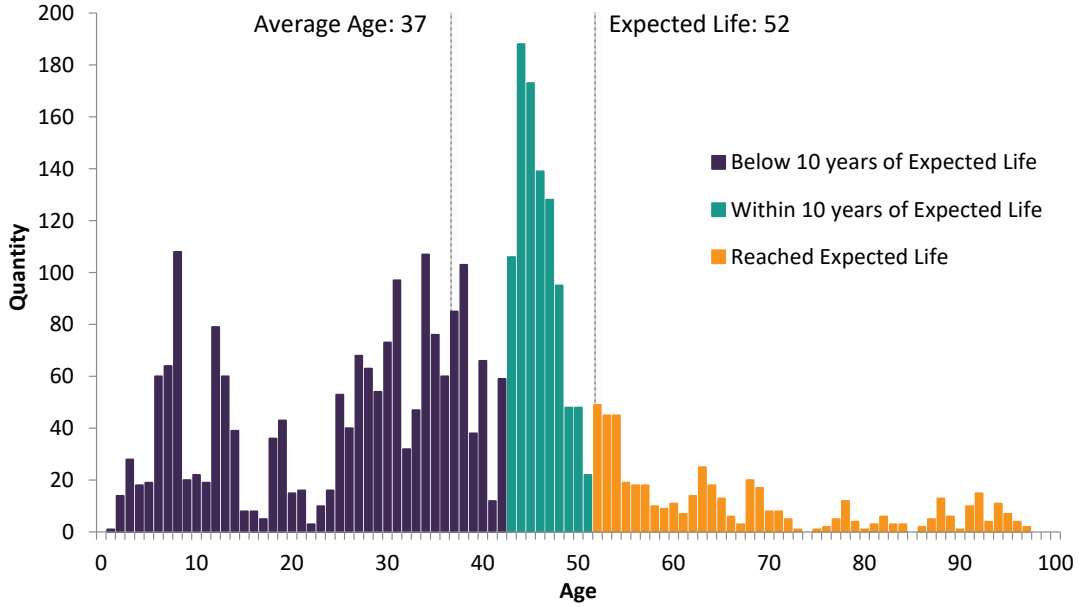


Figure 2: Hydro Ottawa's Vault Transformer Age Demographics[2]

[2] Information as of December 2018
[3] Estimated installation dates may be based on purchase or manufacture date of the equipment.

4. Asset Management Objectives

Vault transformers require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Achieve the transformation of electrical voltage to a level usable by customers
- Achieve good power quality through appropriate setting of tap changers
- Achieve increased reliability due to an enclosed environment provided by the concrete vault

Health, Safety & Environment Stewardship

- Impact employee and public safety due to an asset failure
- Impact environmental stewardship by releasing oil through asset failure

Asset Value

- Impact asset lifecycle cost as an emergency replacement is more costly than planned replacement[4]
- Impact asset lifecycle cost as poor maintenance of a vault that is not owned by Hydro Ottawa may result in damage to Hydro Ottawa owned vault transformers

Resource Efficiency

- Impact resource optimization as a single emergency replacement is less resource efficient than planned replacement which usually has a bank of vault transformers being replaced[4]

Compliance

- Impact compliance with the Government of Canada - SOR/2008-273 - PCB Regulations

In order to monitor and strive to improve the performance of vault transformers, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs were developed by the AMC as targets for optimal distribution system operation.

Table 3: Vault Transformers KPIs

KPI	*Target*
Vault transformer - SAIFI / 100 customers	0.004[5]
% of vault transformers in very poor condition (age based condition as per Section 5)	0%

[4] Assumed based on resource and equipment requirements
[5] Based on a five (5) year average

5. Asset Performance

5.1. Asset Condition

Hydro Ottawa has developed an asset health index for vault transformers that is based solely on age, whereby a very poor condition is assigned to an asset with an age that is greater than or equal to the effective age of the asset.

Table 4: Vault Transformer Condition KPI

KPI	Target	2017
% of vault transformers in very poor condition	**0%**	13.8%

Hydro Ottawa currently does not meet the target of vault transformers in very poor condition shown in Table 4. Hydro Ottawa plans, as detailed within this AMP, to address these transformers through targeted replacement.

5.2. Reliability

Hydro Ottawa tracks the contribution of defective equipment outages by asset class to the overall system average interruption frequency index (SAIFI) per 100 customers (SAIFI x 100). Hydro Ottawa's reliability performance is compared to the KPI target, determined by the five year average, to drive continuous improvement with aim to reduce the number of outages year-over-year.

Table 5: Vault Transformer Reliability KPI

KPI	Target	2014	2015	2016	2017	2018
Vault transformer - SAIFI / 100 customers	**0.004**	0.001	0.002	0.009	0.000	0.009

Hydro Ottawa does not currently meets the reliability target for outages due to defective vault transformers and will continue to monitor reliability metrics for trends and improvements.

5.3. Compliance

Hydro Ottawa prioritized the inspection and oil sampling of vault transformers shortly after the Government of Canada enacted regulations on the manufacturing and use of oil containing PCBs. The inspection and oil sampling allowed Hydro Ottawa to determine which assets required replacing to meet the legislative requirements.

Hydro Ottawa has met the compliance target and is presently compliant for removing all vault transformers which contained oil with PCB levels above that specified in the Government of Canada's - *SOR/2008-273 - PCB Regulations*.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades vault transformers due to various drivers described in Table 6 below, corresponding with the Ontario Energy Board's (OEB) investment categories. Vault transformers are installed as per approved procedures and standards available in the Underground and General sections of Hydro Ottawa's Engineering & Operations intranet website.

While there is generally a single driver prompting the initiation of a project, the affected assets and surrounding area are evaluated to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 6: Drivers for Vault Transformer Installation / Replacement / Removal

OEB Investment Category	*Driver Description*
System Access	• Customer service request for new connection • Third party requests for asset relocations
System Renewal	• Assets replaced due to end-of-life • Assets replaced due to economic benefits or other strategic objectives • Assets damaged by third parties e.g. overloading
System Service	• New or upgraded assets to improve reliability • New or upgraded assets to alleviate capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer and third party requests. These include:

Customer Connections

- Upgrade an existing vault transformer to support service equipment
- New vault transformer installed to support service equipment
- Vault rehab projects where by customer owned integral switch replacements trigger a transformation upgrades

Relocated Assets

- Relocate vault transformer to accommodate work (e.g. building redevelopment)

Table 7 shows the historical vault transformers issued to the field for various activities under System Access.

Table 7: System Access – Vault Transformer Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Customer Connection	47	21	46	27	18
Assets Relocated	0	0	1	3	0

6.1.2. System Renewal

As described in section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a vault transformer failure. Hydro Ottawa replaces vault transformers each year in both a proactive and reactive manor based on feedback from Hydro Ottawa staff through visual inspections and asset failure. Table 8 shows the historical vault transformers issued to the field for various activities under System Renewal.

Table 8: System Renewal – Vault Transformer Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Corrective Renewal	19	25	9	4	1
Planned Renewal	3	3	0	3	0
Assets Damaged by Third Parties	0	0	0	0	0

Corrective Renewal
Vault transformers which pose an immediate or imminent risk to the asset management objectives are repaired under maintenance or replaced under corrective renewal. These assets are identified immediately if the deficiency is visual or through ad-hoc IR scanning. Criteria which determine corrective renewal, in addition to asset condition which causes outages, are shown in Table 9. Where applicable, the vault transformer may be upgraded to align with future plans such as increasing capacity for future customers.

Table 9: Vault Transformer Corrective Renewal Criteria

Emergency Replacement (Immediate Risk)	*Critical Replacement (Imminent Risk)*
Damaged beyond repair	Cracked bushing
Significant loss of oil	Minor oil leak cannot be repaired
Extreme corona detected	Irreplaceable component
Failed IR scan (overheating)	
Operated (popped) pressure flag	

Planned Renewal
Vault transformers which do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on the results of planned inspections, feedback from Hydro Ottawa staff performing work within the vicinity and associated risk. Additionally, vault transformers may be replaced or upgraded in conjunction with planned work for other assets where efficiencies can be gained.

Assets Damaged by Third Parties
Vault transformers which are damaged due to third parties are replaced or repaired immediately after the area is made safe.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by vault transformer work, but may require vault transformers to be installed, upgraded or replaced to accomplish the identified objectives. The drivers of these projects include:

Voltage Conversion
- Reduce Hydro Ottawa's electrical system's energy losses, improve the energy capacity by increasing the supplying voltage and/or reduce replacement costs by decommissioning lower voltage equipment no longer requiring replacement.

Reliability Improvements

- Improve Hydro Ottawa's levels of service by decreasing impact of electrical interruptions

Capacity Upgrades

- Improve Hydro Ottawa's system accessibility for load and energy resource facility customers by removing capacity constraints

Vault transformers are reviewed as part of these projects to determine whether they are adequate to accommodate the project's scope or whether they require being replaced, upgraded or installed. Additionally, the condition of the vault transformers is reviewed to determine if replacement due to end-of-life is anticipated. Vault transformers may be replaced before their end-of-life based on technical requirements or overall economic efficiencies. Table 10 shows the historical vault transformers issued to the field for various activities under System Service.

Table 10: System Service – Vault Transformer Installed / Replaced / Upgraded

Description	*2014*	*2015*	*2016*	*2017*	*2018*
Voltage Conversion	0	0	0	0	0
System Reliability	0	0	0	0	0
System Capacity	0	3	0	0	

6.2. Operations & Maintenance Plan

Vault Transformer Inspection

Hydro Ottawa proactively performs both a passive visual inspection to report deficiencies and a detailed inspection on vault transformers. Hydro Ottawa's employees perform passive visual inspections on vault transformers as additional work takes place within the respective vault.

Hydro Ottawa also inspects vault transformers on a scheduled program defined in VIS0001 *Electrical Equipment Vault Inspection and Maintenance*. This inspection includes IR scanning per GCS0015*Thermographic Scanning of Power Lines and Distribution Apparatus*. Issues found from these inspections are reported to Hydro Ottawa and actioned for remedy. Results from inspections are stored on databases associating the inspection with the specific asset and are accessed through Hydro Ottawa's GIS. The information provided through inspections can be used to determine the asset maintenance and renewal plans.

Any issues or deficiencies that are found through work unassociated with the above inspections are reported by exception as per the intent of ESG0001 *Hydro Ottawa Electrical Distribution Safety Construction Verification Program in compliance with Ontario Regulation 22/04*, so the issue can be rectified

Vault Transformer Repair

Hydro Ottawa performs reactive maintenance and repair to vault transformers when there are minor issues which don't classify the vault transformer as reaching its end-of-life (through the inspection process mentioned above). Typical repairs include replacing failed components which make up the vault transformer and maintenance activities such as cleaning the asset and tightening connections.

6.3. Disposal Plan

Hydro Ottawa disposes or re-uses vault transformers depending on their condition when they are removed from service due to various drivers. Hydro Ottawa only re-uses vault transformers following the testing and inspection per the previously mentioned inspection methods and WTS0002 *Testing Used Distribution Transformers*. The testing also determines where Hydro Ottawa may send the vault transformer to the supplier for refurbishment where Hydro Ottawa recovers value. Where a vault transformer is scrapped, the metal material is disposed of through metal recycling where Hydro Ottawa recovers scrap value. The oil used for insulation is disposed of as per WI-ENV-006 *Hazardous and Liquid Waste Disposal* and WI-ENV-023 *Oil and Oil Filled Equipment Transportation*.

6.4. Contingency Planning

Hydro Ottawa maintains a stock of vault transformers which are used as spares in the case of an emergency. The need for these assets during emergencies can arise from the drivers described in Table 9. This stock allows Hydro Ottawa to replace such vault transformers in a timely manner to minimize the impact on the asset management objectives. Hydro Ottawa strives to maintain a minimum quantity of over 87 vault transformers of various configurations, voltages, and sizes in capital spares to be used during emergencies. Additionally, Hydro Ottawa stocks numerous quantities of various types of vault transformer components. The minimum quantity of vault transformers is based on the asset's usage and the need to have replacement assets should an emergency occur.

In addition to keeping spare assets available, Hydro Ottawa strives to develop strategic partnerships with contractors and equipment suppliers to complement and supplement the core business strengths. This includes identifying multiple suppliers of vault transformers should an issue arise or more assets be required.

7. Future Demand

7.1. System Access

System Access work is requested by third parties and regulators including the Electrical Safety Authority, and it is therefore difficult to accurately forecast future demand. The drivers for System Access are described in section 6.1.1. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual vault transformers to be installed, replaced or upgraded are shown in Table 11.

Costs associated with this work are generally borne by the requesting party with the exception of system expansion which results in an economic evaluation per the OEB's Distribution System Code Appendix B.

Table 11: Forecasted System Access - Vault Transformers Installed/Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Customer Connection	32	32	32	32	32	32	32
Assets Relocated	2	2	2	2	2	2	2

*Estimated Quantities

7.2. System Renewal

System renewal work is driven by failed assets and information provided through inspections as described in sections 6.1.2 and 6.2. Hydro Ottawa plans to continue with existing inspections and therefore forecasts the future demand of vault transformers replaced due to corrective renewal to be in line with historical averages. Vault transformers replaced due to assets damaged by third parties are forecasted based on historical averages.

Hydro Ottawa historically has replaced vault transformers primarily on a reactionary basis due to corrective renewal. However, due to the risk posed by the number of vault transformers in service past or approaching their expected operating life, beginning in 2021 Hydro Ottawa has determined an increased number of vault transformers will require proactive replacement to mitigate the risk. This replacement strategy will prioritize vault transformers based on their age, as well as, levelize the future replacement of the growing and aging fleet of assets. This levelization allows for more predictive forecasting of costs and labour requirements while maintaining an effectively managed asset base. The expected annual vault transformers to be replaced or upgraded are shown in Table 12.

Table 12: Forecasted System Renewal – Vault Transformers Replaced/Upgraded

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Corrective Renewal*	12	12	12	12	12	12	12
Planned Renewal	0	0	25	25	25	25	25
Assets Damaged by Third Parties*	0	0	0	0	0	0	0

*Estimated Quantities

7.3. System Service

System Service work is driven by improvements to the system as described in section 6.1.3. System improvement drivers may require vault transformers to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. The forecasted annual demand for vault transformers is shown in Table 13.

Table 13: Forecasted System Service – Vault Transformers Replaced / Upgraded / Installed

Description	2019*	2020*	2021*	2022*	2023*	2024*	2025*
Voltage Conversion	1	0	0	0	1	7	0
System Reliability	0	0	0	0	0	0	0
System Capacity	0	0	0	0	0	0	0

*Estimated Quantities

7.4. External Factors

Hydro Ottawa reviews external factors which may impact distribution vault transformers and their ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a significant threat to vault transformers. While more resilient than overhead construction, increased rain fall and extreme weather have the capacity to flood the vaults containing vault transformer's leading to lengthen time to access the equipment to perform switching and repairs, as well as, damaged equipment. These events can negatively affect public and employee safety and cause outages negatively affecting Hydro Ottawa's levels of service.

Additionally, during the summer months where system electricity demand is already the highest compared to the rest of the year, increased ambient temperatures and corresponding demand from equipment, such as air conditioning, can put strain vault transformers. An increase in the occurrence of high heat conditions, coupled with continued electrical demand growth can increase equipment overloading and accelerated failure due to overheating. Continued system monitoring and forecasting are required to ensure vault transformers continue to operate safely and provide value through delivering the asset management objectives.

Furthermore, Hydro Ottawa is undertaking a distribution system climate vulnerability risk assessment and developing a *Climate Change Adaptation Plan* with the support of an external consultant. The results of this assessment will be used to assess and update Hydro Ottawa's various practices and standards.

7.4.2. Vault Access

Customer owned vaults present both access and size issues in order for Hydro Ottawa to properly perform work within these locations due to security and changes to historical standards. To mitigate these issues, Hydro Ottawa actively engages customers owning vaults with regards to inspection and maintenance cycles as described in Section 6.2. In advance of work, Hydro Ottawa employees are made aware and plan for any size constraints that may affect required activities. In addition, Hydro Ottawa strives to work with customers to ensure its pace on access issues due to security.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa does not forecast resources based on a specific asset, but rather on a program (e.g. vault renewal) level. These programs may incorporate numerous types of assets. The resource forecasting is accomplished by reviewing historical hours worked, the specific resource type (e.g. underground) and the respective program's cost. This is then applied to the forecasted workload to determine the required resource hours. The model assumes a direct correlation between dollars expended and volume of work. In reality, the elasticity between these variables will be dependent on the unique circumstances for each type of work performed. This model has historically allowed Hydro Ottawa to meet current program needs while planning its workforce to meet future requirements.

Hydro Ottawa ensures it has the adequate resources to complete the forecasted capital and operational plans through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team which is comprised of Directors and Managers across various stakeholder groups and led by the Human Resource division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across the various work segments. Hydro Ottawa's workforce modelling uses elements such as labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, ratio of journeypersons to apprentices, legislated allowance for overtime and environmental factors or business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

Vault transformer assets along with their components are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, over their expected financial useful life of 35 years. The difference between the expected operating life and the financial useful life is that certain drivers require vault transformers to be decommissioned, replaced or upgraded before they have reached full operating life. These projects can be driven by System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's vault transformers is approximately $5.3M[6] which represents 0.8% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). Hydro Ottawa follows capitalization practices on distribution assets per the POL-Fi-013 *Capitalization Policy*, e.g. straight line depreciation. Therefore the assets depreciate annually over their expected financial useful life. The accumulated depreciation of Hydro Ottawa's vault transformers is approximately $0.9M[6].

[6] Information as of March 2018

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in Section 4 used to measure performance of vault transformers in achieving the asset management objectives. The performance of these assets is described in section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with vault transformers.

Hydro Ottawa also addresses issues with vault transformers through the underground standards committee. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to underground assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to vault transformers achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan* (DSP), within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	S Fowler	NO: **IAP0012**	REV: **0**
APPROVED:	L. Heuff		
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Asset Management Plan
Telecommunications

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2020-02-23	SF/LH



Asset Management Plan – Telecommunications (OTN)

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1. Introduction

Hydro Ottawa's telecommunication network allows the distribution system to merge with high-performance communications in order to provide reliable service and awareness of our system. Each of Hydro Ottawa's substations is connected with a dedicated 1 Gigabit connection. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), provide insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets in order to deliver on the overall asset management objectives and associated measures as described in the SAMP. The AMP describes the current condition and performance in order to identify gaps for continuous improvement and establish remedial actions to close them as well. Additionally, an assessment of future demand and drivers which impact the asset(s) and may alter the way they are managed is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy and the associated financial plan.

2. References[1]

Hydro Ottawa Strategic Direction
Hydro Ottawa - POL-ED-IAS0001-01 - Asset Management Policy
Hydro Ottawa - GDS0017 - Hydro Ottawa Owned Fibre Optic Cable: Design and Installation Guidelines
Hydro Ottawa - IAP0022 - Asset Management System Risk Procedure
Hydro Ottawa - IAP0021 - Asset Management System Communication Plan
Hydro Ottawa - IAS0002 - Asset Management System Manual
Hydro Ottawa - IAS0003 - Strategic Asset Management System Plan
Hydro Ottawa - E&O intranet website - Department Processes
Hydro Ottawa - E&O intranet website - Standard Work Methods
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Policies, Guidelines & Design Considerations
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Calculations & Tables
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Materials
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Qualifications
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Construction and Bill of Materials
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Inspection & Maintenance
Hydro Ottawa - E&O intranet website - Fibre Optic Cable Archives
Hydro Ottawa - POL-Fi-013 - Capitalization Policy
Hydro Ottawa - POL-IT-001 - Cybersecurity Policy
Hydro Ottawa - POL-IT-002 - IM&IT Governance

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's telecommunications infrastructure. While the activities described are over the entirety of the asset's life, the AMP details specific information with respect to future demand until 2025. A high level diagram outlining the prime telecom assets are shown in Figure 1 and the equipment is shown in Figure 2. The assets described in Table 1 provide value to Hydro Ottawa and stakeholders through completing their respective functions.

The scope of this AMP includes the equipment necessary for the local connection of Hydro Ottawa's distribution facilities with high-performance communications. This includes the Optical Transport Network (OTN) and access infrastructure that allows local connections to the network, referencing Figure 1, layer one and two respectively. This AMP does not include layer three which represents local communication equipment such as the Remote Terminal Units (RTUs) connected to distribution assets within a substation. Unless specified, referring to the telecom network includes the respective components below, along with fibre optic cable, jumpers and transceivers (SFPs), which allow for the successful use of the asset.

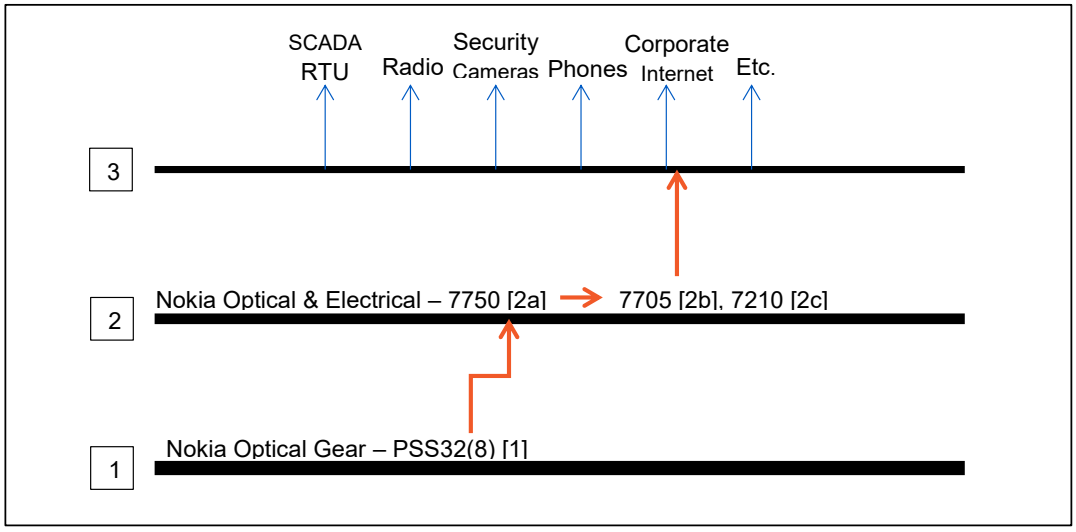


Figure 1: Asset Overview High Level Diagram



1 **2a** **2b** **2c**

Figure 2: Telecommunications Network Equipment

Table 1: Telecom Equipment Functions

Asset Overview	*Figure Number*	*Component*	*Function*
Optical Transport Network (OTN) Gear	1	PSS32(8)	Optical Backbone – Used to provide multiple paths between core sites and switches the traffic without converting it to electrical signals

Asset Overview	*Figure Number*	*Component*	*Function*
Network Access Equipment	2a	7750	Service Aggregation Router – Used at core sites to terminate access rings. Routes traffic locally or to optical backbone and onto next core site until final destination.
	2b	7705	Service Access Router – Used at every substation to on-board traffic onto each access ring. All critical traffic is directly on 7705SAR-8 and is connected to a DC power supply at the station (i.e. SCADA traffic is critical)
	2c	7210	Service Access Switch – Used at every substation to on-board less critical traffic onto each access ring (i.e. corporate network, cameras, IP phones, etc.)
Local Network Connections	N/A	N/A	Local traffic to SCADA RTUs, radios, security cameras, phones, corporate internet, etc.

An example of the telecommunication network is shown below in Figure 3 and 4 showing the traffic from a SCADA RTU and the redundancy in the network.

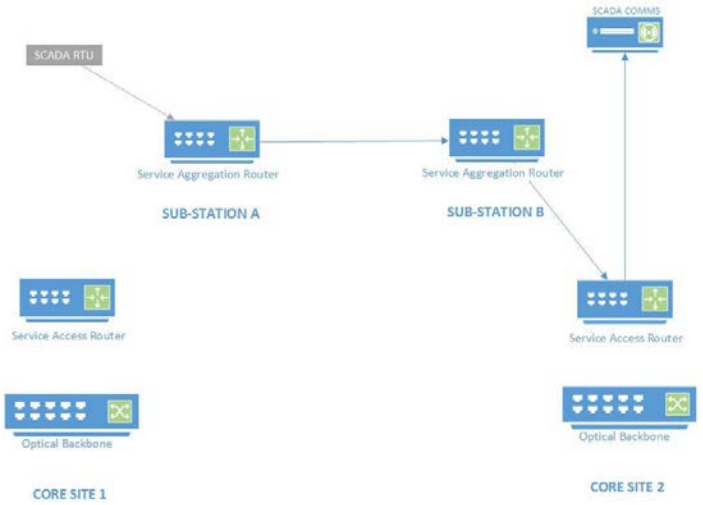


Figure 3: Normal Traffic Flow from RTU

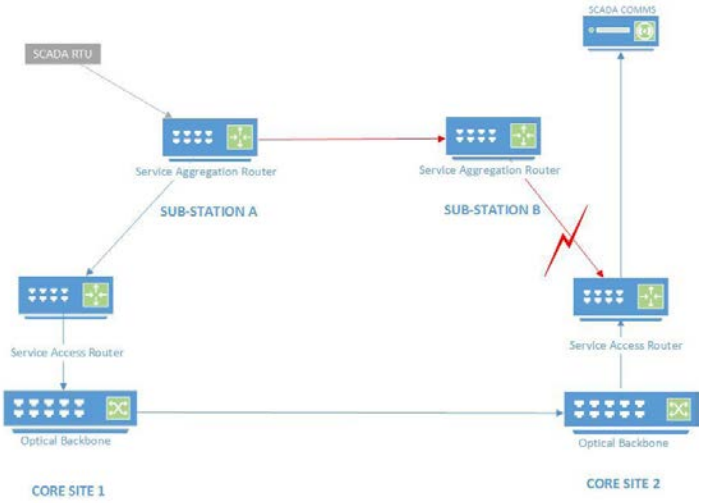


Figure 4: Traffic flow from RTU with Network Failure

The telecom network uses Multi-Protocol Label Switching (MPLS). This allows for different types of traffic on the same network. MPLS uses labels to identify traffic, provide security and it allows for data to be separated into private VPN tunnels using IPSec. Additionally, MPLS further allows for traffic of different types to be given different priority and Quality of Service (QOS). This priority further allows for the growth of non-critical traffic as the policies will ensure that critical SCADA and protection traffic remains in priority. This routing technique directs traffic with short path labels instead of long network addresses that require complex lookups in routing tables. This creates a versatile network and allows for growth alongside Hydro Ottawa's distribution and corporate assets.

Cybersecurity is a part of all technology acquisitions at Hydro Ottawa. All telecom equipment procurement and network management follows the Cybersecurity Policy POL-IT-001 under Information Management & Information Technology (IM&IT) governance.

Hydro Ottawa's Geographical Information System (GIS) stores the installation dates, loop identifiers, and duct location of all Hydro Ottawa owned fiber cables. Additionally, an add-on to the GIS software, called Fiber Optic Works, holds detailed information such as the location of splices (with splice type, typical loss, bandwidth, and circuit number), circuitry, racking/equipment information, jumpers and power supplies for the network. Hydro Ottawa plans to continue to maintain these records.

4. Asset Management Objectives

Telecommunication infrastructure and equipment requires effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives:

Levels of Service

- Impact on service reliability, through support of system remote monitoring and operating

Health, Safety & Environmental Stewardship

- Ensure construction standards are followed for maintenance, repairs and new builds
- Impact employee and public safety to allow for reliable communication to and from field devices and stations
- Impact environmental stewardship through support of reduced travel requirement.

Asset Value

- Achieve reduced costs due to economic effectiveness of Hydro Ottawa owning its own telecommunications infrastructure
- Increased reliability and reduced cost of consolidation of all telecom systems into a single network

Resource Efficiency

- Where redundancy is present in the network, overtime personnel is not required when a failure occurs as the repair can be made on the next business day
- Telecom network provides the necessary requirements for reliable remote operability of devices in the field and stations via the supervisory control and data acquisition (SCADA) system

In order to monitor and strive to improve the performance of the telecom infrastructure, Hydro Ottawa reviews the key performance indicator (KPI) shown in Table 2 which impacts the asset management objectives.

Table 2: Telecom - Fiber Network KPIs

KPI	*Target*	*2014*	*2015*	*2016*	*2017*	*2018*
Network Uptime (%)[2]	≥98.5	N/A[3]	N/A[3]	99.97	100.00	100.00

[2] This percentage represents the average network uptime for both Hydro Ottawa owned (assets covered in this AMP) and leased network equipment as the Telecom Master Plan project is still in progress until December 2021. Once this project is complete, the majority of the network will be owned by Hydro Ottawa. This number is reported as a monthly metric for IT Operations under the SCADA Network Performance Measure.
[3] The Telecom Master Plan project was not in progress this year.

5. Asset Performance

5.1. Asset Condition

All fibre optic cable installation followed standard GDS0017 *Hydro Ottawa Owned Fibre Optic Cable: Design and Installation Guidelines*. Currently, there is not a health index standard for Hydro Ottawa owned fiber optic network and components. It is expected that the Network Functions Manager for Packets (NFM-P) continuously reports on the health of the network in terms of both connectivity and packet loss and triggers alarms when any network segment or element is down. During installation, Optical Time-Domain Reflectometer (OTDR) reports are recorded for every circuit entering a site in the network loop. This validates the initial dB loss per segment to ensure cable installation meets industry standards. Visual inspections are completed during installation: an OTDR with a Visual Inspection Probe is used to capture a close up image of the end of the connector and evaluates the cleanliness before the connection is made.

Due to the nature and redundancy of the telecom network, there is a run to failure asset maintenance strategy. Therefore there is minimal planning around the asset condition after installation. There are equipment spares in stock at the Hydro Ottawa facility for immediate replacement and Nokia will replace any spares within the next 60 days as part of the spare strategy defined in the Service Level Agreement (SLA).The fibre network and equipment is recorded into Hydro Ottawa's Geographical Information System (GIS) for data tracking (see Section 3).

Possible cable conditions that would require repair (repair by splice) would be a result of cable deterioration or third party incident causing fractures to the cable. Table 3 refers to the fiber cable and equipment financial lifetime. As mentioned above, Hydro Ottawa plans to replace equipment due to failure whereas pre-emptive replacements due to end of product service life are not considered economical.

Table 3: Telecom Network Equipment Lifetime

Equipment	*Lifetime (Years)*
Optic Cable	25
PSS32	8
7705	8
7750	8
7210	8

Table 4 refers to the KPIs with regards to the condition of the assets. These are recorded during installation for acceptance testing and reference during troubleshooting if required.

Table 4: Telecom Network Component Health KPIs

KPI	*Target*
Connector loss	≤0.5 dB
Splice loss / km of fiber	≤0.25 dB
Average segment loss	≤3 dB

5.2. Reliability

The telecom network is built with equipment that supports multiple use cases. Due to the redundancy present in the network, if a failure occurs, the network will react by rerouting the traffic as required with no immediate repair required. The network has also been designed to prioritize SCADA traffic from a station RTU over other traffic from that station and utilizes an uninterrupted power supply for optimal reliability. This enables the telecom network to support the control and monitoring of our grid, which contributes to the management of our distribution assets.

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades telecom fiber optic infrastructure due to various drivers described in Table 5 below, corresponding with the Ontario Energy Board's (OEB) investment categories. All fibre optic cable installation followed standard GDS0017 *Hydro Ottawa Owned Fibre Optic Cable: Design and Installation Guidelines.* The approved procedures and standard is available on Hydro Ottawa's Engineering & Operations intranet website.

While generally there is a single driver initiating a project, the affected assets and surrounding area are reviewed to determine and ensure additional needs and future plans are taken into consideration. Through this planning, multiple drivers across investment categories may be addressed. This ensures value is achieved over the asset's full lifecycle.

Table 5: Drivers for Telecommunication (fiber optic network) Installation / Replacement

OEB Investment Category	*Driver Description*
System Access	• System Expansion • New/upgraded local network connections
System Renewal	• Assets replaced due to failure • Assets installed to maintain or improve network redundancy • Asset damaged by third parties
System Service	• New or upgraded assets to improve reliability (software) • New or upgraded assets to improve capacity constraints (increase bandwidth)

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by the following:

System Expansion

- New substation added to distribution system requiring communication via fiber network
- New or moved Hydro Ottawa headquarters (core site)

Additional Local Connections

- Additional local connections such as:
  - SCADA RTU
  - Radio for field devices
  - Security Cameras/security access cards
  - Phones
  - Corporate Internet
  - Wholesale Meters

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by:

Asset Replaced due to Failure

- Such as transceivers (SFPs), cards, or damaged fiber optic cable

Maintaining Redundancy

- With system expansion, the network can be established to the RTU however the end goal is to also install necessary connections for redundancy

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing fibre optic network driven by:

Increase capacity

- To meet bandwidth demands
- To sustain bandwidth and redundancy

System Management

- Upgrade software to be compatible with equipment added to the network

6.2. Operations & Maintenance Plan

As discussed in Section 5.1, the telecom network has a run to failure maintenance strategy. The software tool that monitors the network can be upgraded but needs to be compatible with all equipment in the network. As part of the initial Network acquisition, Hydro Ottawa has paid for two future upgrades and an annual maintenance plan.

Failures in the network will trigger alarms and notify Hydro Ottawa's network administration team. Hydro Ottawa provides initial system support and contacts Nokia for more advanced system support as needed.

6.3. Disposal Plan

When failure occurs and a piece of equipment is deemed no longer approved for use in the network, the item is sent to a third party company who is responsible for recycling or disposing where applicable.

6.4. Contingency Planning

As mentioned in Section 4, one of the asset management objectives is to continue to develop and maintain redundancy throughout the network. Therefore if a failure occurs, the network will reroute traffic to the best available path and continue operations as usual. The failure can then be addressed as part of normal business operations (business hours) instead of emergency work.

In the event that redundancy is not available, Hydro Ottawa maintains a stock of all required telecom equipment which can be used as spares in the case of an emergency. This stock allows Hydro Ottawa to replace fiber equipment in a timely manner to minimize the impact on the asset management objectives.

In addition to keeping spare assets available, Hydro Ottawa has a service level agreement with Nokia that will repair or replace any piece of equipment within 60 days. Therefore where spares are used, there is a plan to maintain the required stock of equipment.

7. Future Demand

7.1. System Access

System Access work is driven by the approval of expansion to the distribution system that requires network access. It's important for telecom to be a part of the planning process to ensure the connection is engineered and designed appropriately.

7.2. System Renewal

System Renewal work is driven by assets that have run to failure or have been damaged based on the data from the system monitoring software. It is also driven by sustaining the asset management objective of network redundancy.

Upcoming System Renewal

- Increase physical redundancy to core sites
- Add redundancy around new connections

7.3. System Service

System Service work is driven by improvements to the system as described in Section 6.1.3. System improvement drivers may require telecom infrastructure to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets. All connections in the network are designed to provide stations with at least 1GB of bandwidth. In the event that the demand increases, and is identified in the software tool, an analysis of the connection would be completed in order to drive the changes required to increase the bandwidth. Additionally, a newly built station will need to be designed to ensure there is room for the telecom equipment to be racked, cabled and powered according to the standard.

The construction of the Cambrian Station includes System Service work for telecommunication infrastructure.

7.4. Additional Factors

Hydro Ottawa reviews external factors which may impact the telecom infrastructure and its ability to continue delivering value in support of the asset management objectives.

7.4.1. Climate Change

Climate change has the ability to pose a threat to telecom infrastructure, though all equipment used is expected to handle poor environment conditions and is installed to be securely in place within its contained environment such as substations. However, abnormal temperature and humidity can factor into equipment life expectancy.

With an increase in harsh weather conditions on the distribution system, an increase in distribution automation could be required. This would need to be added to the telecom network. Additional redundancy could also be required to enhance the reliability and avoid prolonged outages of the telecom network which allows for remote operability and visibility with the distribution system through SCADA when harsh weather systems hit the service territory.

These events can lead to damaged assets and a negative impact to Hydro Ottawa's levels of service. Hydro Ottawa's distribution system climate vulnerability risk assessment did not identify any specific risks related to this asset, and there are no current climate specific adaptations for this asset. This assessment will be periodically reviewed should climate risks change, such that future adaptations are identified.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa forecasts time for resources based on the plan for upcoming projects that require work to the telecom network. The network team that supports the network should be a part of the planning phases for distribution system expansion projects. These resources are needed to engineer and design the network accordingly to meet asset management objectives. Contract resources will be leveraged as needed.

8.2. Financial

Hydro Ottawa telecom assets, described in Section 3, are capitalized per the POL-Fi-013 *Capitalization Policy* using a pooled method, due to their quantity, price and commonality, based on their expected financial useful life of 8 years and 25 years for fiber optic cable. The difference between the expected operating life and the financial useful life is that certain drivers require stations and/or segments of the telecom network to be extended, replaced or upgraded before they have reached full operating life. These projects can be driven by facility relocations, new substations, equipment lifecycle and/or required Cyber Security improvements.

Hydro Ottawa undertakes maintenance and capital work to support the asset management objectives, as well as to support third party requests. Hydro Ottawa does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the annually produced/updated Distribution System Plan.

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in Section 4 used to measure performance of the telecom network in achieving the asset management objectives. The performance of these assets is described in Section 5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with the telecom network.

Areas of improvement for telecom include the ability of adding layers of redundancy to the network over time to both new and existing sites. Additionally, situational awareness of the network can be improved as further Hydro Ottawa assets are added to the network. Nokia also offers add-ons to the software that could improve the performance data provided by the network and generate reports to enhance the identification of areas of improvement. Improvements to the capacity of the network can be made through the installation of additional connections between stations and core sites and/or the upgrade to the line cards within the equipment. Finally, if required through change in Cyber Security policies, full network wide encryption (over and above the Virtual Private Network channels used) can be implemented with the addition of both hardware and software modules at each site.

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the Asset Management System (AMS) are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS003 Section 9.3.

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to telecommunications achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan (DSP)*, within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa		TITLE: **Procedure**	
RECOMMENDED:	A. Diotte	NO: **IAP0013**	REV: **0**
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Asset Management Plan
Revenue Meters

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2020-02-23	AD/LH



Asset Management Plan – Revenue Meter

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1. Introduction

Hydro Ottawa's revenue meters are used to measure the electricity consumed by its residential, commercial, and industrial customers. This vital service is required for the continued economic growth and improved quality of life provided through the use of electricity. The assets are essential to the business practices and for the organization to deliver on the goals set out in Hydro Ottawa's Strategic Direction.

The Asset Management Plan (AMP) is a multi-year plan which includes the specific activities, strategies and timeframes required to achieve Hydro Ottawa's asset management objectives. The AMP is developed utilizing principles from the Asset Management Policy and direction from the Strategic Asset Management Plan (SAMP). Input from various internal stakeholder groups, through the Asset Management Council (AMC), also provides insight into specific assets and the activities required to manage them.

The AMP details the specific level of service required by the assets to deliver on the overall asset management objectives and associated measures described in the SAMP. The AMP describes current asset condition and performance, with the goal of identifying gaps for continuous improvement and establishing remedial actions. An assessment of future demand and drivers which impact the asset management is also provided. Finally, the AMP identifies the lifecycle strategies and activities associated with the asset(s), the resources that are required to fulfill the strategy, and the associated financial plan.

2. References[1]

Hydro Ottawa - Strategic Direction
Hydro Ottawa - Distribution System Plan
Hydro Ottawa - POL-ED-IAS0001-01 - Asset Management Policy
Hydro Ottawa - IAS0002 - Asset Management System Manual
Hydro Ottawa - IAS0003 - Strategic Asset Management System Plan
Hydro Ottawa - IAP0022 - Asset Management System Risk Procedure
Hydro Ottawa - IAP0021 - Asset Management System Communication Plan
Hydro Ottawa - ECG0008 - Distribution Voltage and Power Quality Guideline
Hydro Ottawa - ISO 9001 - Quality Management System
Hydro Ottawa - E&O intranet website - Department Processes
Hydro Ottawa - E&O intranet website - Standard Work Methods
Hydro Ottawa - E&O intranet website - Metering Policies, Guidelines & Design Considerations
Hydro Ottawa - E&O intranet website - Metering Calculations & Tables
Hydro Ottawa - E&O intranet website - Metering Materials
Hydro Ottawa - E&O intranet website - Metering Qualifications
Hydro Ottawa - E&O intranet website - Metering Construction and Bill of Materials
Hydro Ottawa - E&O intranet website - Metering Inspection & Maintenance
Hydro Ottawa - E&O intranet website - Metering Archives
Hydro Ottawa - POL-Fi-013 - Capitalization Policy
Government of Ontario - Electricity Act of 1998
Government of Ontario - Ontario Energy Board Act
Ontario Energy Board - Distribution System Code
Government of Canada - Electricity and Gas Inspection Act
Measurement Canada - S-S-06 - Sampling Plans for the Inspection of Isolated Lots of Meters in Service
Measurement Canada - S-E-02 - Specifications for the verification and the reverification of electricity meters
Measurement Canada - E-24 - Policy on approval and use of 2½ element metering

[1] Most recent revisions of the referenced documents are to be used

3. Asset Overview

This AMP covers Hydro Ottawa's revenue metering assets. More specifically, it outlines the operations and maintenance performed over the lifecycle of the asset, and provides information about the future demand until 2025. An illustrative example of revenue meter components can be seen in Figure 1. These assets provide value to Hydro Ottawa and stakeholders through completing their respective functions described in Table 1. Unless specified, a revenue meter includes the components outlined in Table 1. Furthermore, Table 2 outlines the hierarchy of the asset class, sub-classes and components within Hydro Ottawa's distribution system.

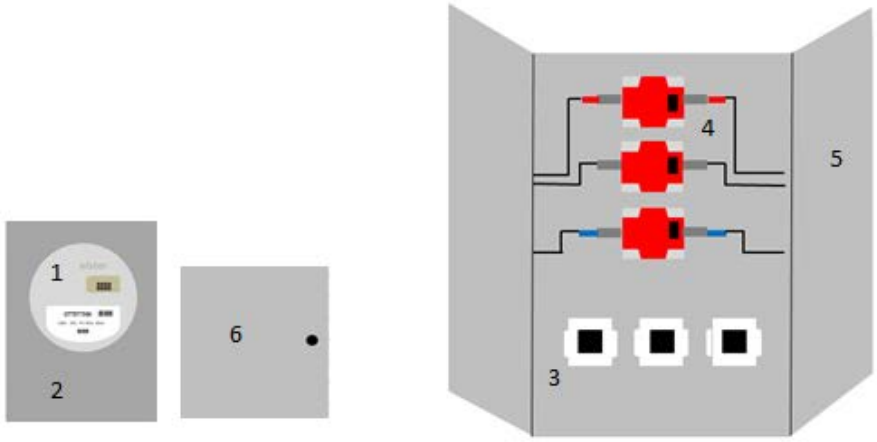


Figure 1: Metering System (Illustrative Purposes Only)

Table 1: Revenue Metering Component Functions

Figure Number	Component	Function
1	Revenue Meter	The revenue meter is provided by Hydro Ottawa and is used to measure the usage or demand of the service. Revenue meters can be self-contained or transformer-rated.
2	Meter Base	The meter base is provided by the customer and is required by Hydro Ottawa to house the revenue meter.
3	Voltage Transformers	Voltage transformers are a high accuracy class of electrical devices used to isolate or transform voltage levels for measurement purposes. The primary winding of the transformer is connected to the primary voltage, and the revenue meter is connected to the secondary circuit.
4	Current Transformers	Current transformers are a high accuracy class of electrical devices used to isolate or transform current levels for measuring purposes. The primary winding of the transformer is connected to the primary current and the revenue meter is connected to the secondary circuit.
5	Transformer Cabinet	The transformer cabinet is a metal enclosure which contains the fuse block, wiring, current transformers and voltage transformers.
6	Communications Cabinet	The communications cabinet is a metal enclosure which houses the modem and components necessary to communicate with the meter data acquisition systems.

Figure Number	Component	Function
Not Shown	Meter Data Acquisition System	Meter Data Acquisition Systems (MDAS) are used to collect data from the revenue meters remotely. The data collected is sent to downstream processing systems. MDAS can also return error codes and assist in flagging or troubleshooting meter communication failures.

Table 2: Class, Sub-class and Components of Revenue Meters

Class	*Sub-Class*	*Components Belonging to or Supporting the Sub-Class*
Revenue Meters	Self-Contained	Revenue Meter, Meter Base, Meter Data Acquisition System
	Transformer-Rated	Revenue Meter, Meter Base, Voltage Transformers, Current Transformers, Communications Cabinet, Transformer Cabinet, Meter Data Acquisition System

Revenue meters are one of the largest Hydro Ottawa asset classes. As shown in Figure 2, the total number of HOL revenue meters is 335,236 as of December 2018.Of these 335,236 meters, 328,607 are self-contained and 6,629 are transformer-rated, this is shown in graphical form in Figure 2. The age distribution the revenue meters is shown in Figure 3.

Self-contained and transformer-rated meters have distinct functions. Self-contained meters measure electricity usage and demand for the majority of residential and small commercial customers. They can operate under currents of up to 200 amps and voltages of up to 600 volts. Transformer-rated meters measure electricity consumption (kWh) and demand (kW) for commercial and industrial service points, as well as at distribution and transmission stations. They require instrument transformers to measure voltages up to 46,000 volts and currents up to 8,000 amps.

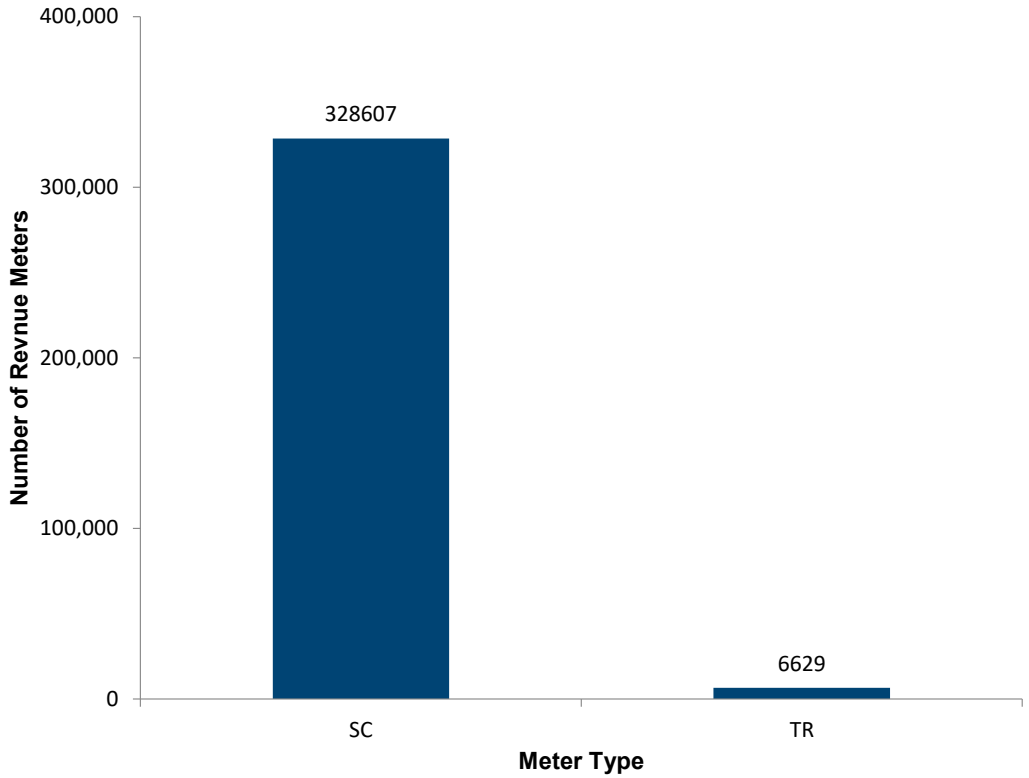


Figure 2: Number of Transformer-Rated (TR) and Self-Contained (SC) Meters in the revenue metering asset class.

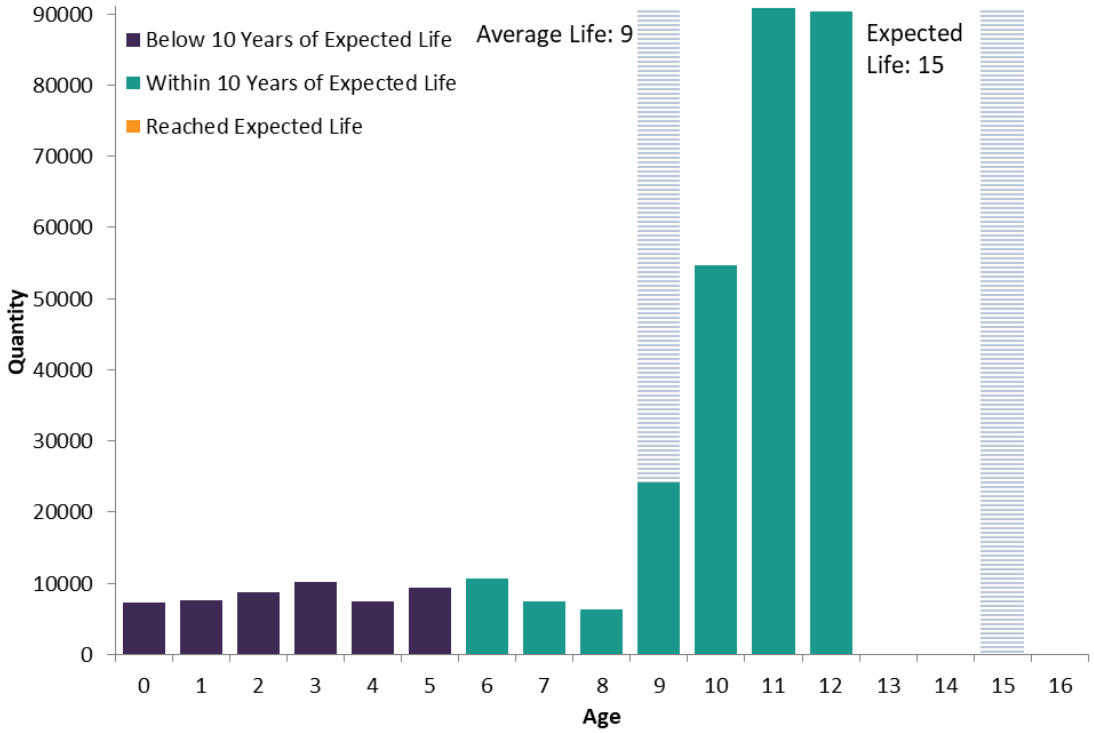


Figure 3: The age distribution of HOL Revenue Meters.

Based on Hydro Ottawa POL-Fi-013 Capitalization Policy, the financial life of a revenue meter is currently set to 15 years. Meter manufacturers' have conducted accelerated life testing and have demonstrated that meters have a useful life of 25 years; at the time of this documents publication the manufacturer was unable to provide their testing reports. These accelerated life testing do not account for technological obsolescence, which is a primary driver for the increasingly shortened useful lives of meters seen in the field. Replacing meters after 15 years also allows Hydro Ottawa to update its fleet, benefiting in changes in metrology and communication firmware in meters.

4. Asset Management Objectives

Revenue meters require effective asset management to ensure they deliver value to Hydro Ottawa by supporting the success of the asset management objectives. These assets and their management have the ability to achieve or impact the following asset management objectives

Levels of Service:

- Optimize operations to provide complete, accurate and timely revenue metering for the HOL customer base.
- Ensure that meters are compliant with the standards set out by all external regulatory bodies.
- Perform proactive maintenance to ensure the continued accuracy and functionality of metering equipment.
- Collaborate with customers and third parties to provide revenue metering features to support their current and future needs.
- Achieve accurate power quality monitoring, in compliance with Hydro Ottawa ECG0008 *Distribution Voltage and Power Quality Guideline* when requested by the customer.
- Facilitate grid accessibility to permit contributions from independent producers.

Asset Value

- Standardize the metering instrumentation used across the distribution system.
- Achieve reduced costs through equipment amalgamation or elimination.
- Minimize inventory levels.
- Implement reliable infrastructure to increase cost effectiveness.
- Invest in training for evolving asset management protocol via the meter technician apprenticeship program.
- Further leverage smart meter technology to enable enhanced outage communications, data analytics and system modeling

Resource Efficiency

- Use Mobile Workforce Management to effectively schedule work and optimize travels routes.
- Review labour demand to accomplish operational objectives, business and labour supply, as well as provide continuing support to the metering apprenticeship program.
- Install remote disconnect meters to eliminate on site disconnection.
- Streamline inventory management through meter stock code reduction.
- Replace meter phone lines with cell modems to increase communication reliability and reduce maintenance requirements.
- Outsource sample group and due meter testing to a third party contractor to optimize workforce management and reduce maintenance costs.
- Track low and zero consumption transformer-rated meters to flag potential non-conformance meters and reduce the resources required for field visits and cross reads.

Health, Safety & Environmental Stewardship

- Achieve public safety by containing electrical equipment through the use of sealed enclosures.
- Enhance public safety by minimizing asset failure.
- Promote environmental stewardship through diligent asset management and recycling programs.

Compliance

- Metering operations comply with the *Electricity and Gas Inspection Act*, the *Electricity Act of 1998* and the *Ontario Energy Board Act.*
- Conduct annual internal and external quality assurance audits to evaluate operational compliance with ISO 9001 standards.
- Audit select wholesale revenue meter points annually to ensure compliance with the *Independent Electricity System Operator Market Rules.*

In order to monitor and strive to improve the performance of revenue meters, Hydro Ottawa reviews the key performance indicators (KPIs) shown in Table 3 which impact the asset management objectives. KPIs developed by the AMC as targets for optimal distribution system operation.

Table 3: Revenue Meter KPIs

KPI	Target
Cross Read Investigations	100%
Sample Groups Reverified	100%
Due Meters to be Reverified	100%
Monthly Average Communication Failure Rate (%) for Industrial and Commercial Transformer-Rated Meters	95%
Monthly Average Communication Failure Rate (%) for Wholesale Transformer-Rated Meters	95%

5. Asset Performance

5.1. Asset Condition

To annually evaluate the condition of the metering assets, a metering failure index was developed**.** This index, shown in Figure 4, represents the percentage of installed meter assets that fail annually. At this time, a testing methodology does not exist within the industry to develop a health index for revenue meters. Hydro Ottawa is however currently in discussions with CEATI regarding future development of such an indicator.

Meter failures (non-conformance meters) can be a result of hardware or software failure. Though no internal targets are defined, the failure index does provide insight into failure trends, and may prompt changing workforce management processes or contacting the meter manufacturer for further information with regards to meter failures.

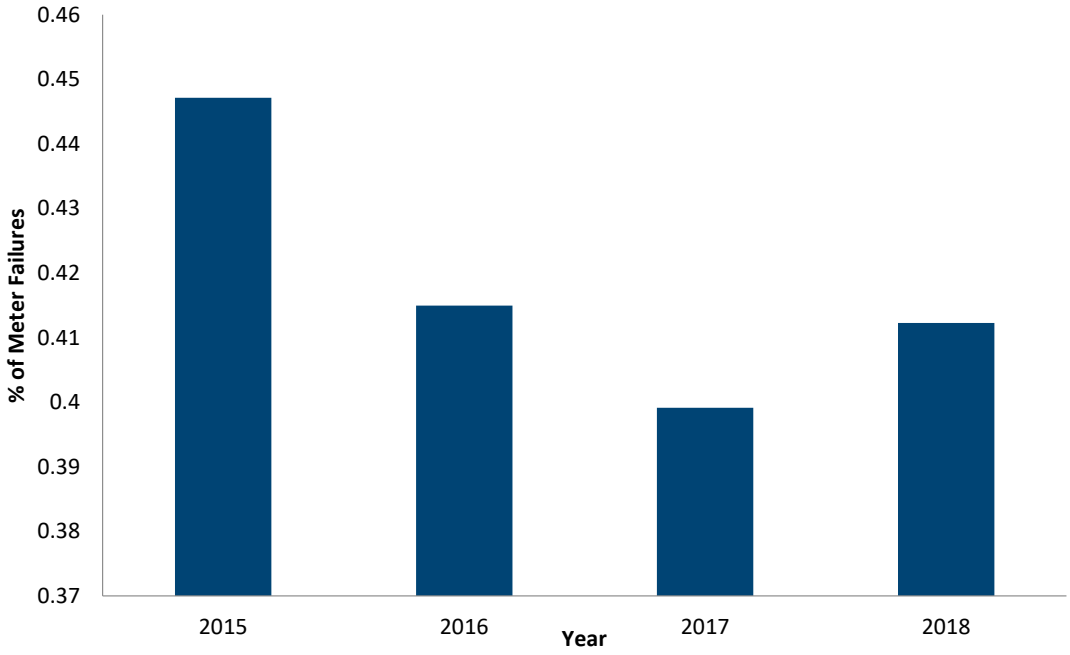


Figure 4: Meter Failure Index of Revenue Meters

5.2. Reliability

Hydro Ottawa tracks both the completion of cross read investigations and communication success rate of meters as key indicators of asset reliability. Failure to complete the targeted number of cross read could result in potential instrument transformer inefficiencies and billing inaccuracies. Failure of the meter to communicate with Meter Data Services (MDS) results in billing inaccuracies and potential customer dissatisfaction. Communication failure is also an indication of meter malfunction. Details of the cross read maintenance program are provided in section 6.2 below

Table 4: Revenue Meters Reliability KPIs

Description	Target	2014	2015	2016	2017	2018
Cross Read Investigations	100%	100%	100%	100%	100%	100%
Monthly Average Successful Communication Rate (%) for Industrial and Commercial Transformer-Rated Meters	95%	N/A	96.11%	95.87%	95.36%	96.08 %
Monthly Average Successful Communication Rate (%) for Wholesale Transformer-Rated Meters	95%	N/A	N/A	N/A	97.57%	97.67%

5.3. Compliance

All of Hydro Ottawa revenue meters are sealed as per Measurement Canada requirements; these seals have an expiry period of 6 to 12 years depending on the meter type and can be resealed as per Measurement Canada specifications. Those meters whose seals are "due" and meters which are selected at random as a representative sample of meters from its lot are tested as per Measurement Canada Policy *S-E-02, Specifications for the Verification and the Reverification of Electricity Meter* to ensure accuracy. Successful testing of due meters will extend the seal of each individual meter and the successful testing of sampled meters will extend the seal of all meters within the meter lot. The compliance KPI is targeted at 100% to ensure that Hydro Ottawa is meeting Measurement Canada requirements for meter accuracy.

Table 5: Revenue Meter Compliance KPIs

KPI	Target	2014	2015	2016	2017	2018
Number of Sample Groups Reverified	100%	100%	100%	100%	100%	100%
Due Meters Reverifed	100%	100%	100%	100%	100%	100%

6. Asset Lifecycle Management

6.1. Capital Plan

Hydro Ottawa installs, replaces and upgrades metering installations due to various drivers. These drivers can be divided into three categories outlined in Table 6, corresponding to the Ontario Energy Board (OEB)'s three investment categories. Revenue meters are installed as per GCS0008 *Revenue Metering* Specification and the approved procedures and standards available in the Metering sections of Hydro Ottawa's Engineering & Operations intranet website.

Table 6**:** Drivers for Revenue Meter Installations, Replacement and Disposal

OEB Investment Category	Driver Description
System Access	Customer request for a new or upgraded service Provide metering to facilitate bi-directional grid contributions
System Renewal	Assets replaced due to failure, third party damage, non-conformances or end-of-life Assets replaced due to economic benefits or other strategic objectives
System Service	New or upgraded assets implemented to improve reliability New or upgraded assets implemented to improve capacity constraints

6.1.1. System Access

Hydro Ottawa performs System Access work which is driven by customer, third party requests, and compliance with regulator's requirements including the Electrical Safety Authority. These include:

Customer Connections

- Upgrade an existing service capacity or provide additional metering features.
- Install a meter to energize a new connection.
- Install a bidirectional meter to provide system access for customers with grid contribution capabilities.

The number of system access installations completed annually from 2014 to 2018 is displayed in Table 7.

Table 7: System Access – System Access Meter Installations

Description	2014	2015	2016	2017	2018
Grid Access Connections (Bi-Directional metering)	52	43	49	40	39
New or Upgraded Connections at the Customer Request	6,637	6,298	5,483	5,183	6,122

6.1.2. System Renewal

Hydro Ottawa performs System Renewal work which is driven by asset failure, economic benefits, or strategic investments. As described in Section 4, Hydro Ottawa's asset management objectives and corresponding corporate strategic objectives can be impacted through a revenue meter failure. Hydro Ottawa replaces revenue meters each year in both a proactive and reactive manner. System renewal can be subdivided into corrective renewal work and planned renewal work.

Table 8: System Renewal – Revenue Meters Replaced or Upgraded

Description	2014	2015	2016	2017	2018
Corrective Renewal	1,386	1,499	1,391	1,338	1,382
Planned Renewal	0	0	0	0	0

Corrective Renewal
Revenue meters posing an immediate or imminent risk to the asset management objectives are identified by a communication failure, meter technician assessments or customer inquiries. There are six drivers of corrective renewal for revenue metering:

- meter failure
- tampering or broken seal
- customer billing requests
- communication failure
- physical damage
- other causes

The criteria defining each driver are outlined in Table 9. Meters requiring corrective renewal are deemed non-conformance meters and are removed and either repaired and returned to service or disposed of.

Table 9: Revenue Meter Corrective Renewal Criteria

Corrective Renewal Category	Description
Meter Failure	Flashing A Phase, accuracy error, EPROM error, flashing C phase, programming or clock error, battery failure, blank display
Tampering or Broken Seal	Cut seal, suspicions of tampering with meter, theft of power
Customer Inquiry	Concerns with inaccurate billing
Communication Failure	Modem failure, RF problem, antenna malfunctioning, remote disconnect malfunctioning, meter not communicating with gatekeeper
Physical Damage	Fire on premise, meter dropped, paint on the meter covering the display, vandalism, broken component (ex: jaw, meter cover),
Other	Testing at the request of a technician or staff member, nondescript reason

The total number of meters requiring corrective renewal each year is displayed in Table 8.

Planned Renewal
Revenue meters that do not pose an immediate or imminent risk to Hydro Ottawa's asset management objectives are replaced based on forecasted improvements to the grid and projected customer benefit. No such improvements occurred over the last five years; future planned renewal is detailed in Section 7.2.

Assets Damaged by Third Parties
Revenue meters which are damaged due to third parties are replaced or repaired as soon as possible. Hydro Ottawa does not actively measure how many revenue meters are damaged by third parties at this time, the corrective renewal numbers reported above include physical damage values that include revenue meters damaged by third parties. Should occurrences of third party damages grow in large quantities Hydro Ottawa will re-evaluate the monitoring of them as their own category.

6.1.3. System Service

Hydro Ottawa performs System Service work to improve the existing distribution system. These projects are not typically driven by meter work, but may require meters to be installed, upgraded or replaced to accomplish the identified objectives.

Hydro Ottawa has invested $6.8 M to install remote disconnect meters from 2016-2020, according to the schedule displayed in Table 10 and Table 14 in Section 7.3. The remote disconnect project enables turning the meter power on and off at a service point remotely, as opposed to a meter technician having to do it manually on site. This initiative has reduced the percentage of field disconnections from 55% in 2016 to 41% in 2018. This corresponded to an annual savings of $115K in 2018 and reduces the field workers exposure to hazards during physical disconnection.

Table 10: System Service – Remote Disconnect Meters Installed

Description	2014	2015	2016	2017	2018
Remote Disconnect Meters Installed	N/A	N/A	2,491	6,913	6,625

6.2. Operations & Maintenance Plan

Hydro Ottawa performs three key operations and maintenance operations to ensure maxmium meter population efficiency.

Transformer-Rated Meter Cross Reading
Hydro Ottawa performs a number of cross read on all transformer-rated meters; this number is determined by the Quality Council at their annual meeting. A cross read is done to ensure that the ratio of the primary current to secondary current of instrument transformers deviates less than 3% from the manufacturer specifications. This ratio directly affects the billing multiplier used to bill customers. Cross reads therefore ensure that instrument transformers are operating efficiently and that customers are being billed accurately.

Sample Meters and Due Meters
Measurement Canada Policy *S-S-06, Sampling Plans for the Inspection of Isolated Lots of Meters in Service,* outlines the procedures for sampling and resealing a meter lot. A meter lot is comprised of meters with the same manufacturer, model, type, technical specifications, status at time of previous inspection and seal year. A representative sample of meters from each lot is selected at random and tested based on measurement Canada Policy *S-E-02, Specifications for the Verification and the Reverification of Electricity Meter.* Compliant sample groups receive a seal year extension and are returned to service.

Due meters do not belong to a homogenous lot and are resealed individually.

Non-Conformance Testing
Non-conformance meters are identified via customer inquiries, technicians on site visits, or flagged by Meter Data Services (MDS). In compliance with ISO 9001, non-conformance meters are removed and replaced with a functioning meter at the service point. Removed meters that comply with Hydro Ottawa Temporary Deviation 13 can be placed directly in a hold bay and disposed of after 30 days. Otherwise, the meter will be tested, and can be returned to service or disposed of after a 30 day hold period.

6.3. Disposal Plan

Hydro Ottawa disposes of revenue meters at the end of their life. These meters are recorded and retired, and the meter is disposed of through outsourced bulk component recycling. The recycling company destroys any proprietary, confidential customer information in the meter. They also recover valuable materials including metal, electronic components, meter displays and hard plastic coverings. This ensures that the disposal process of revenue meters minimizes environmental impact.

6.4. Contingency Planning

Contingency metering stock is ordered based on the forecasted quarterly demand for capital work and the number of meters required to replace sample group testing meters. The percentage of stock allotted as replacements for transformer-rated and self-contained meters, respectively, is displayed in Table 11[2].

Table 11: In stock, Installed and Contingency Stock for Revenue Meters

Revenue Meter Class	In Stock	Installed	Contingency Stock (%)
Self-contained	9,209	332,404	2.71
Transformer-rated	1,371	6,657	20.64

[2] As of March 2019

7. Future Demand

7.1. System Access

System Access work is requested by third parties and therefore is difficult to accurately forecast future demand. The drivers for System Access are described in Section 6.1.2. Hydro Ottawa uses historical trends, but also strives to work with stakeholders such as developers and the City of Ottawa to stay informed on upcoming projects and plans which may affect assets through stakeholder and committee meetings. The combination of this information is used to estimate future asset demand under this investment category. The expected annual revenue meters to be installed, replaced or upgraded are shown in Table 12.

Table 12: Forecasted System Access – Revenue Meters Installed / Replaced / Upgraded

Description	2019	2020	2021	2022	2023	2024	2025
Grid Access Connections (Bi-Directional metering)*	45	45	45	45	45	45	45
New or Upgraded Connections at the Customer Request*	5,945	5,945	5,945	5,945	5,945	5,945	5,945

*Based on 5 year historical data ending in 2018

7.2. System Renewal

System renewal work is driven by failed assets and strategic infrastructure updates. Detailed below are nine (9) system renewal projects that Hydro Ottawa plans to implement between 2019 and 2025. The work schedule outlined in Table 13 is designed to minimize the costs associated with asset de-recognition.

Table 13: Forecasted System Renewal - Revenue Meters Replace / Upgraded

Description	2019	2020	2021	2022	2023	2024	2025
Corrective Renewal*	1,399	1,399	1,399	1,399	1,399	1,399	1,399
Planned Renewal	0	0	9,830	8,090	8,453	9,173	8,975

*Based on 5 year average ending in 2018

7.3. System Service

System Service work is driven by improvements to the system as described in Section 6.1.3. System improvement drivers may require revenue meters to be installed, replaced or upgraded to achieve the desired outcome. Therefore, the future asset demand is determined by the prioritized projects which require work to be completed on these assets.

The remote disconnect initiative enables powering the meter on and off remotely, as opposed to a meter technician manually disconnecting at the service point. This subsequently reduces the maintenance cost and improved meter technician safety by reducing their exposure to site hazards.

Table 14: Forecasted System Service – Revenue Meters Replace / Upgraded / Installed

Description	2019	2020	2021	2022	2023	2024	2025
Remote Disconnection	7,500[3]	7,500[4]	3,500	3,500	3,500	3,500	3,500

7.4. External Factors

Hydro Ottawa reviews external factors which may impact revenue meters and their ability to continue delivering value to support the asset management objectives. These external influences include regulatory bodies, meter manufacturers, site accessibility and HOL system assets. Hydro Ottawa remains actively engaged with the CEA and EDA as a means of remaining abreast of changes in the industry and potential impact to operations.

7.4.1. Regulatory Bodies

Regulatory bodies dictate protocols which can affect the asset management of the revenue metering fleet. These regulatory bodies include Measurement Canada, Independent Electricity System Operator (IESO) and the Ontario Energy Board (OEB).

Measurement Canada requires that the metrology accurately registers and reports the electricity usage at a given service point. They also determine the mechanical and electrical specifications of a meter, in addition to testing protocols for meter verification and reverification. Changes in Measurement Canada guidelines will thus impact the technical specifications, communication protocols and operation and maintenance practices for revenue meters.

As Ontario's designated reliability coordinator, the IESO sets out the standards, policies and procedures associated with wholesale revenue metering. All wholesale metering operations must comply with the IESO Market Rules.

The *Ontario Energy Board Act of 1998* established the Ontario Energy Board (OEB) as the independent energy regulatory body of Ontario. The OEB determines consumer electricity rates and advocates for consumer interests in both the short and long term in Ontario. Consumer rates, set by the OEB, provide funding for HOL infrastructure updates. Changes in the OEB organizational direction can in turn impact funding available to implement metering projects over a given rate application period.

7.4.2. Meter Manufacturer

Potential changes to proprietary communication protocols and product development determined by the metering manufacturer could affect both the type and functionality of the meters available for use by HOL. Communication with meter manufacturers to understand new innovations and their potential impact to the existing system prior to adoption is essential in mitigating any potential risks from this external factor.

[3] Projected Number of Installations

7.4.3. Site Accessibility

Meters are often housed in secured metering bases or enclosures. Enclosures can be found in hazardous or inaccessible locations. This can negatively impact the ability of meter technicians to access services which need to be maintained, repaired or updated. This can result in missed appointments, lost time or an inability to complete field activities.

7.4.4. HOL Distribution & IT Communication Assets

HOL revenue metering operations are influenced by requirements for managing other Hydro Ottawa distribution & IT communication assets. Metering communication planning is aligned to and provides input into the Telecommunications Master Plan, which was developed and is maintained by the Grid Technology group within Hydro Ottawa. As an integral step to improving metering communications, the transition from standard copper phone line communications (POTS) to LTE communications will improve the communication success rate of meters with MDS, resulting in increased reliability reporting and decreased troubleshooting for both revenue metering and MDS.

8. Resource Plan

8.1. Labour Resources

Hydro Ottawa forecasts metering labour resources based on the requests for HOL capital work and upcoming sample and due meters. Maintenance work is completed on a reactive basis and therefore advanced workforce planning is conducted based on historical averages.

On a macro scale, Hydro Ottawa ensures that it has adequate resources to complete the forecasted capital and operational work through the use of workforce planning and modelling. Workforce planning is reviewed by the core planning team. This team is comprised of Directors and Managers across various stakeholder groups and led by the Human Resources division. The goal of the analysis is to determine gaps and identify proactive strategies to address them using insight across various work segments. Hydro Ottawa's workforce modelling incorporates labour demand and supply, internal and external movements and forecasted retirements. Factors such as cost, labour market availability, and ratio of journey persons to apprentices, legislated allowance for overtime, environmental factors and business considerations are also taken into account. All of these factors are used to identify the best combination of internal resources, overtime utilization, hiring and contracted services to deliver Hydro Ottawa's services and programs.

8.2. Financial

HOL undertakes maintenance and capital work to support the internal asset management objectives and third party requests. HOL does not forecast expenditures on a per asset basis, but rather on a program level. The forecast of operation and maintenance expenditures can be found in the annually produced Electricity Distribution Budget: Operation and Maintenance. The forecast of capital expenditures can be found in the capital expenditures section of the Distribution System Plan.

Revenue metering assets are capitalized as per the POL-Fi-013 *Capitalization Policy* over their financial useful life of 15 years. The difference between the expected operating life and the financial useful life is that certain drivers require meters to be decommissioned, replaced or upgraded before they have reached the financial useful life. These drivers can be categorized as System Access, System Renewal or System Service work. If completed under System Renewal or System Service, the derecognized value of the assets is taken into consideration for the evaluation of the respective project.

The existing net book value of Hydro Ottawa's revenue meters is approximately $25.28M, which represents 3.7% of Hydro Ottawa's distribution assets within the scope of the Asset Management System (AMS). The accumulated depreciation of Hydro Ottawa's revenue meters to date is approximately $16.95M.

9. Continuous Improvement

Performance monitoring and reporting enables fact based decision-making in line with the Asset Management Policy's principles. Hydro Ottawa creates and monitors a number of key performance indicators (KPIs) to inform and improve business decisions. Hydro Ottawa has a variety of metrics described in Section 4 used to measure performance of revenue meters in achieving the asset management objectives. The performance of these assets is described in Section5. The performance is compared to the KPI targets to drive continuous improvements within the various groups and sections which make up asset management, as well as, enhance processes, asset management and business strategy planning. In addition, IAP0022 *Asset Management System Risk Procedure* will be used to address fundamental risks and opportunities with distribution poles, fixtures and overhead conductor.

Hydro Ottawa addresses issues with metering operations through the metering standards committee. The standards committee is made up of various relevant stakeholders. The standard's committee is made up of various relevant stakeholders and reviews, maintains and updates design, maintenance, construction and material specification technical standards relevant to metering assets. Additionally, the Distribution Policies and Standards section leads the trial of new equipment and practices with input from various stakeholders including Operations and Asset Planning sections on new technology, new or emerging industry practices and new tools and equipment solutions

10. Implementation

10.1. Roles and Responsibilities

Asset management activities within the AMS are to be completed by the designated roles. The various roles within the AMS and their responsibilities are defined below.

Asset Owner: Shall be the Chief Electricity Distribution Officer or competent delegate. The Asset Owner is responsible for supporting the AMS and providing top level visibility, as well as making high-level strategic decisions and approvals such as approving asset management objectives.

Asset Manager: Shall be the Director, Distribution Engineering and Asset Management supported by the Director, Distribution Construction and Maintenance and the Director, System Operations and Grid Automation, or competent delegate(s). The Asset Manager is responsible for the operation and continual improvement of the AMS, making strategic decisions such as determining the balance of asset cost, risk and performance to meet the asset management objectives. In addition, the Asset Manager shall:

- Maintain the asset management objectives within the AMS;
- Approve and prioritize specific asset management strategies;
- Ensure there is sufficient support, resources and an engaged and competent workforce to deliver the AMS; and
- Review, monitor and report performance of the AMS to the Asset Owner and other members of the Executive Management Team.

Asset Service Provider: Shall be Manager-level staff and below within roles associated with asset management activities. Asset Service Provider's responsibilities include:

- Defining and managing the strategies, standards, operational planning, maintenance planning, and capital planning of Hydro Ottawa's assets; and
- Efficiently implementing the operational plans, maintenance plans and capital works plans for Hydro Ottawa assets.

Asset Management Council: Shall include representatives from across the organization and provide governance of the AMS as defined in IAS0003 Section 9.3

Business Support: Additional groups and sections whom are responsible for enabling asset management objectives and the success of the AMP.

10.2. Communication and Usage of the AMP

The AMP is delivered to internal stakeholders following the process defined in the IAP0021 *Asset Management System Communication Plan*. It shall be accessible, transparent and open for sharing internally. In particular, the Asset Owner, Asset Managers and Asset Service Providers shall communicate how the asset management activities with respect to distribution poles achieve Hydro Ottawa's asset management objectives to all relevant stakeholders. Communication shall be two-way enabling stakeholders to provide input and feedback that may contribute to the enhancement of the AMP.

The AMP is linked to Hydro Ottawa's Strategic Direction, the Asset Management Policy, the SAMP and other governing AMS documents. The AMP is primarily used by Hydro Ottawa staff involved in asset management at Hydro Ottawa as a detailed document on the asset management activities used to deliver Hydro Ottawa's asset management objectives. In addition, the AMP is used to inform appropriate asset management components, such as Hydro Ottawa's *Distribution System Plan (DSP)*, within the regulatory submission.

10.3. Review of the AMP

The AMP is reviewed annually, updated as required by the Asset Manager and approved by the Asset Owner. It may also be updated and approved more frequently to reflect changes to Hydro Ottawa's business environment (e.g. changes in regulatory compliance).

HydroOttawa	TITLE: **Procedure**	
RECOMMENDED: M. Flores	NO: **GDG0016**	REV: **0**
APPROVED: B. Hazlett		
REV. DATE: 2020-02-20		

Project Evaluation Procedure

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2020-02-20	MF/BH

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1. Introduction

The Project Evaluation is a component of Hydro Ottawa's Capital Expenditure Process. In order to consistently evaluate projects that will be included in the Capital Expenditure Plan, Hydro Ottawa requires a procedure for evaluation of projects and alternatives ensuring delivery on the Asset Management Objectives.

2. References

Hydro Ottawa – Asset Management Plans
Hydro Ottawa – GDG0015 – Project Prioritization Procedure
Hydro Ottawa – GRG0002 – Worst Performing Feeder Methodology
Hydro Ottawa – IAS0003 – Strategic Asset Management Plan
Hydro Ottawa − POL-ED-IAS0001-01 – Asset Management Policy

3. Scope

Hydro Ottawa's Capital Expenditure Process, includes phases which are executed following the Asset Management Process:

- Project Concept Definition
- Project Evaluation
- Project Review
- Project Optimization
- Project Execution

This document describes the procedure used for the Project Concept Definition, Project Evaluation and Project Review Phases followed by projects under the System Renewal and System Services Investment Categories. The Project Optimization phase is described in GDG0015.

4. Definitions, Abbreviations, and Acronyms

C55 − Copperleaf's Asset Management Software
CCRAs − Connection Cost Recovery Agreements
DSC − Distribution System Code
ERF − Energy Resource Facility
HONI – Hydro One Networks Inc.
IESO – Independent Electricity System Operator
IRRP − Integrated Regional Resource Planning

5. Project Concept Definition

The Project Concept Definition phase gathers all internal and external drivers to describe the needs of the company's organizational environment. Concept projects and project alternatives are created to meet requirements, mitigate or remove risk, and meet Asset Management Objectives. Table 1 outlines the description of the drivers by Investment Category. System Renewal and System Service Investment Categories are described below:

- **System Renewal** - Involve replacing and/or refurbishing system assets to extend the original service life of the assets and thereby maintain the ability of the distributor's distribution system to provide customers with electricity services.

● **System Service** - Modifications to a distributor's distribution system to ensure the distribution system continues to meet distributor operational objectives while addressing anticipated future customer electricity service requirements.

Table 1 - Drivers by Capital Investment Category

Investment Category	Driver	Description
System Renewal	Assets at End of Service Life i. Failure ii. Failure Risk iii. Substandard Performance iv. High Performance Risk v. Functional Obsolescence	i. Asset no longer meets functional requirements ii. Asset is at risk to no longer meet functional requirements iii. Asset still meets functional requirements; however, falls below standards for operability or efficiency iv. Asset is at risk of failure in a way that can cause harm or damage to other equipment or assets or would put the distribution system in a detrimental state v. Asset is functionally obsolete with no spare parts, tools, and/or software to continue operation
System Service	Capacity Constraint	Requirement for additional capacity (station transformation or circuit) due to planned or realized load increases
	Reliability	Requirements driven by poor distribution system performance such as abnormally (high) duration or frequency of interruptions
	System Operability	Requirements for improved system operability and visibility

6. Project Evaluation

The Project Evaluation phase creates business cases in support of the project alternatives. Each alternative is valued based on Hydro Ottawa's Corporate Strategic Objectives using the Value Model, described below, in order to assess the project's alternatives based on their value. The evaluation of project alternatives is completed within Copperleaf's industry leading Asset Management software C55.

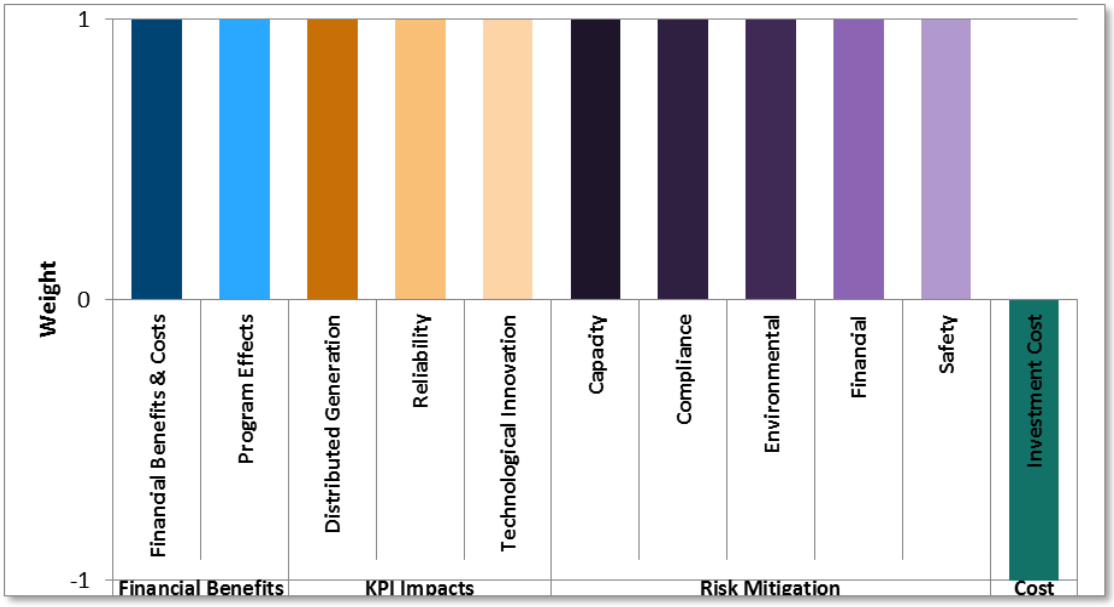
Project concepts and their alternatives are then reviewed to determine if they are mandatory projects. Mandatory projects are typically dictated through the Distribution System Code or the Electricity Act. They range from customer connections to line relocations. These projects are prioritized if they pose immediate concerns to health & safety, environment, or constrain the operation of the system and may move directly to the Execution phase, potentially taking precedence over planned projects and causing deferral or delays. Otherwise, the projects make their way into the Project Review phase before being prioritized.

Project alternatives are then scored by identifying their risk and/or benefit as it relates to Hydro Ottawa's Asset Management Measures through the use of the Value Model. The evaluation Value Model is comprised of eleven Value Measures grouped into four Value Categories as follows:

- Financial Benefits
    - Financial Benefits & Costs
    - Program Effects
- Key Performance Indicator (KPI) Impacts
    - Distributed Generation
    - Reliability
    - Technological Innovation
- Risk Mitigation
    - Capacity
    - Compliance
    - Environmental
    - Financial
    - Safety
- Cost
    - Investment Cost

Each of the Value Measures is normalized to the same scale where 1 value point is approximately equal to $1,000. This means that within the Value Function, each of the Value Measures (except Investment Cost) is weighted with the same value of +1. Investment Cost is a negative contributor to the Value Measure and as such is weighted with a value of -1, as shown below.

Figure 1 - Value Category Weighting



The Value Measures for each project are computed for each year (e.g. the benefits or risks in one year can be different than the next e.g. the risk of a poor condition asset failing increases with time) and are then converted into a single number by taking the present value back to the current fiscal year using the system defined discount rate (5.89%). This means that if a project has a negative value, the cost of the project outweighs its benefits.

The following sections outline the details for the calculation of each of the Value Measures.

6.1. Financial Benefits

6.1.1. Financial Benefits & Costs

The Financial Benefits & Costs are computed in dollars and then normalized to the Value Measure by dividing by 1000.

This Value Measure is calculated using the following equation, and variable definitions are listed in Table 2.

$$Financial\ Benefits\ \&\ Costs\ = (CLAB * HLR) + (OLAB * HLR * 10) + CCST + (OCST * 10) - (OADD * 10)$$

Table 2 – Financial Benefits & Costs Variables

Variable Name	Description
CLAB	Capital Labour Saved (hours)
OLAB	O&M Hours Saved (hours)
HLR*	Hourly Labour Rate (dollars/hour)
CCST	Other Capital Cost Savings (dollars)
OCST	Other O&M Savings(dollars)
OADD	Additional O&M Costs** resulting from this investment (dollars)

*Hourly labour rate (HLR) is $80/hours; and
**O&M Costs are weighted at 10:1 to Capital Costs.

6.1.2. Program Effects

Program Effects utilizes the results of the Program Analytics, refer to Project Optimization section, and is incorporated into the project value where applicable.

6.2. KPI Impacts

6.2.1. Distributed Generation

Hydro Ottawa prioritizes Energy Resource Facility (ERF) investments based on customer requests and follows regulated timelines for response and connection.

Hydro Ottawa strives to integrate all proposed residential and commercial customer generation projects into the grid. Several projects are proposed every year and Hydro Ottawa works with project managers and the customer to integrate the proposed generation into the distribution system. The process for accepting these projects involves: analyzing the generation capacity of the connecting feeder and interface transformer; verifying that the relevant station transformer can accept reverse flow; ensuring that the short circuit changes and voltage fluctuations will cause no material impact on either the distribution or transmission grid; and reviewing the proposed single line diagram, electrical protection scheme and site plan for adherence to all Hydro Ottawa, ESA and IESO standards and requirements. In the event that the proposed generation connection is not possible, Hydro Ottawa works with the customer to provide a solution. This solution may involve expanding the distribution system to meet customer needs or relocating the project to a more fitting property. Where work on the distribution system is required for the connection, the project is coordinated to ensure regulatory timelines are met while optimizing crew time.

Hydro Ottawa also prioritizes investments within its system which help to enable the connection of ERFs. If a given project benefits the ability to connect ERFs then 30 value units are applied to aid in prioritization.

6.2.2. Reliability

The following information is collected specific to each investment:

Table 3 – Reliability Variables

Variable Name	Description / Question Answered
FAIL	How many failures per year will be avoided by implementing this investment? (based on historic rates of failure)
PEAK	For each of the failures, what would be the expected peak load lost, or in the case of redundant equipment the peak load at risk (kW)
DUR	What is the average duration of the outage caused by the failures? (hours)
DURR	If this is redundant equipment, and there is a failure, what is the duration of the period for which redundancy will be lost? (hours)
NCUS	What is the average number of customers impacted by each failure?
TYPE	Customer Type, choose: • Residential • Mixed Residential / Commercial or • Commercial / Industrial
WORS	Has this feeder been identified on the Worst Performing Feeder Report in the past 2 years, OR has this area been identified as an area of concern?

The Reliability measure is then calculated through a sequence of steps:

6.2.2.1. Customer Interruption Cost

Costs associated with interruptions are assigned based on customer type and the frequency and duration of the interruption as outlined in Table 4.

Table 4 – Customer Interruption Costs

Metric / Customer Type	Residential	Mixed Residential / Commercial	Commercial / Industrial
Frequency Cost per kW	2.00	20.00	20.00
Duration Cost per kWh	4.00	20.00	30.00

6.2.2.2. Outage Duration

The duration of the outage is calculated using the following equation, and variable definitions are listed in Table 3:

$$Duration = DUR + (0.05 * DURR)$$

DURR has been included with an impact of 5% since it is possible that a second failure occurs during this time creating an interruption. Computing the likelihood of a secondary failure is complex and varies from situation to situation, so 5% has been selected as a reasonable expectation, and has been used by Copperleaf at other utilities.

6.2.2.3. Customer Cost of Outage Duration

The Cost of Customer Minutes of Interruption is computed as:

$$cmiCost = FAIL * Duration * 60 * NCUS * \$1min$$

Where Duration is calculated in 6.2.2.2.

The Cost of Customer Minutes of Interruption is converted to a cost using a factor of $1 per minute of interruption. This value has been derived using the figures for Mixed Residential / Commercial provided in Table 4 as follows:

$$\begin{aligned} Cost\ per\ minute &= Duration\ Cost\ (\$kWh) * Power\ Consumption(kWh) * 60min \\ &= 20 * 3 * 60 \\ &= \$1min \end{aligned}$$

Where an assumed average consumption of 3kWh has been used as derived Hydro Ottawa statistics from 2013: 7570 GWh billed and 315,000 customers.

6.2.2.4. Frequency Cost

Frequency is computed as:

$$frequencyCost = FAIL * PEAK * Frequency\ Cost\ per\ kW$$

6.2.2.5. Duration Cost

Duration Cost is computed as:

$$durationCost = FAIL * PEAK * Duration * Duration\ cost\ per\ kWh$$

6.2.2.6. Reliability Cost

Reliability Cost is computed based on the highest of cmiCost, frequencyCost and durationCost as:

$$reliabilityCost = max(cmiCost, frequencyCost, durationCost)$$

6.2.2.7. Reliability Value

Reliability Value is then computed from the Reliability Cost using:

$$Reliability\ Value = reliabilityCost(1 + WORS * 0.25) * 1000$$

If the feeder impacted has been identified as a Poor Performing Feeder, as defined in GRG0002 – Worst Performing Feeder Methodology, in the last 2 years or has been identified as an area of concern the value is inflated by 25% and to convert the measure from dollars to units the value is divided by 1000.

6.2.2.8. Technological Innovation

The Technological Innovation measure is computed as:

$$Technological\ Innovation = 10 * TI1$$

Table 5 – Technological Innovation Variables

Variable Name	Question Answered	User Selection	Value
TI1	Does this investment introduce or apply new technology that has never been used at Hydro Ottawa before? (Does not include enhancements to existing technology)	Yes	1
		No	0

6.3. Risk Mitigation

The Value of Risk Mitigation is computed using the same methodology for all 5 Value Categories:

- Capacity
- Compliance
- Environmental
- Financial
- Safety

To compute the value, the Baseline Risk and the Residual Risk is specified and the Value is calculated as follows:

$$Value\ of\ Mitigated\ Risk = \ Baseline\ Risk - Residual\ Risk$$

Baseline Risk is the risk present if the investment is not completed and Residual Risk is the risk present if the investment is completed.

For both the Baseline Risk and the Residual Risk, the Consequence and Probability are specified based on the Risk Categories and Probabilities, Table 6 and Table 7, and are converted to unit values using the Risk Matrix in Figure 2.

Table 6 – Risk Categories

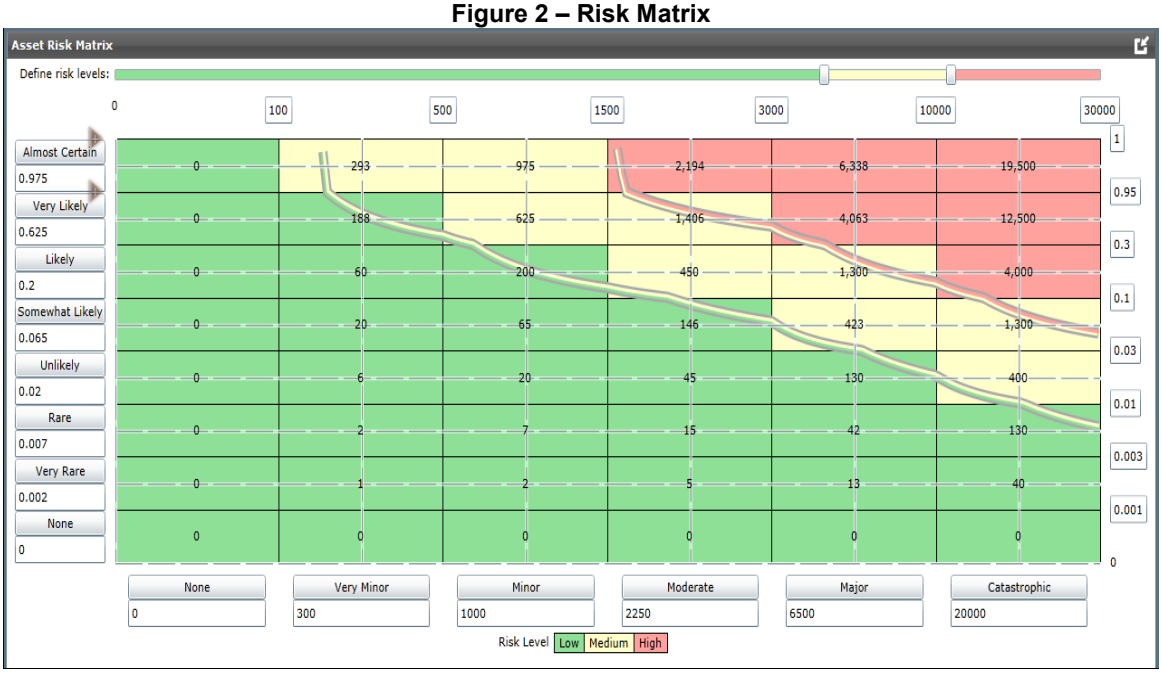
Risk Category	Consequence					
	Catastrophic	Major	Moderate	Minor	Very Minor	None
Capacity	Unable to service a new load	Can supply all load but exceeding thermal limits	Can supply all load but exceeding planning limits	N/A	N/A	Able to supply load without exceeding planning limits
Compliance	Federal/Provincial: Regulated (including OEB, CSA). Including voltages exceeding the standard levels defined in the Conditions of Service	N/A	Municipal: Regulated (local level through Municipal by-laws)	Corporate/Other: Corporate or other requirements, including replacement of recalled equipment, and equipment no longer operating as originally designed	Legislation Pending: May become regulated in the future (i.e. bills announced in parliament or pending legislation)	None: no corporate or legal requirements
Environmental	Release of more than 2000L of oil	Release of 1000L to 2000L or oil	Release of 200L to 1000L of oil	Release of 100L to 200L of oil	Release of less than 100L of oil	Immaterial consequence
Financial	>$10M annually	>$3M annually	>$1.5M annually	>$500k annually	>$100k annually	<$100k annually
Safety	Possibility of injury has been mitigated by operating restriction where the	Possibility of injury has been mitigated by	Possibility of injury has been mitigated by	Possibility of injury has been mitigated by operating restrictions where	Possibility of injury has been mitigated by	Immaterial consequence

Risk Category	Consequence					
	Catastrophic	Major	Moderate	Minor	Very Minor	None
	cost of those restrictions are >$10M or result in >10M CMI annually	operating restrictions where the cost of those restrictions are >$3M or result in >3M CMI annually	operating restrictions where the cost of those restrictions are >$1.5M or result in >1.5M CMI annually	the cost of those restrictions are >$500k or result in >500k CMI annually	operating restrictions where the cost of those restrictions are >$100k or result in >100k CMI annually	

Table 7 – Risk Probability

Probability							
Almost Certain	Very Likely	Likely	Somewhat Likely	Unlikely	Rare	Very Rare	None
Imminent: >95% chance of occurring this year	Greater than 30% chance of event occurring this year	Greater than 10% chance of event occurring this year (e.g. 1 in 10 year event)	Greater than 3% chance of event occurring this year (e.g. 1 in 33 year event)	Greater than 1% chance of event occurring this year (e.g. 1 in 100 year event)	Greater than 0.3% chance of event occurring this year (e.g. 1 in 333 year event)	Greater than 0.1% chance of event occurring this year (e.g. 1 in 1000 year event)	Event unlikely to occur in next 1000 years

Figure 2 – Risk Matrix



To illustrate the use of the Risk Matrix, the replacement of a station-class transformer without modern oil containment by a station-class transformer with modern oil containment would mitigate a risk of 'Catastrophic' environmental consequence, with a probability from 'Very Rare' to 'Unlikely', depending on the age and condition of the asset. The replacement of a distribution-class transformer would mitigate the risk of 'Very Minor' consequence, with a probability from 'Rare' to 'Somewhat Likely', depending on the age and condition of the asset. Approximate annual risk mitigation scores for these scenarios would be 130 and 2, respectively. The two lines in Figure 2 delineate the regions of each Risk Level in the Risk Matrix: Low, Medium, and High.

6.4. Cost

6.4.1. Investment Cost

The investment cost is entered in dollars and then normalized to the Value Measure scale by dividing by 1000.

6.4.2. Mandatory Compliance Investments

Investments that have been identified as mandatory or “must do” based on being an imminent safety or regulatory concern will be flagged and will pass through at the top of the optimization process. These investments will still be scored based on the Value Measures and will typically show mitigated risk under the Compliance or safety category.

7. Project Review

During the Project Review phase the valuation of each project is reviewed individually and compared to similar projects to ensure a consistent approach has been applied. As well, the relative ranking of projects, compared to one another, is assessed to validate that projects have been ranked according to expectations based on engineering judgement. If discrepancies are found the project valuation will be corrected.

HydroOttawa		TITLE: Procedure	
RECOMMENDED:	M. Flores	NO: GDG0015	REV: 0
APPROVED:	B. Hazlett		
REV. DATE:	2020-02-20		

Project Prioritization Procedure

REVISION SHEET

Revision	Description of Change	Date	Initial
0	Original Document	2020-02-20	mf/bh

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1. Introduction

The Project Prioritization is a component of Hydro Ottawa's Capital Expenditure Process. In order to consistently prioritize projects included in the Capital Expenditure Plan, Hydro Ottawa requires a procedure to ensure delivery on the Asset Management Objectives.

2. References

Hydro Ottawa – Asset Management Plans
Hydro Ottawa – GDG0016 – Project Evaluation Procedure
Hydro Ottawa – IAS0003 – Strategic Asset Management Plan
Hydro Ottawa − POL-ED-IAS0001-01 – Asset Management Policy

3. Scope

Hydro Ottawa's Capital Expenditure Process, includes phases which are executed following the Asset Management Process:

- Project Concept Definition
- Project Evaluation
- Project Review
- Project Optimization
- Project Execution

This document describes the procedure used for the Project Optimization phase. The Project Concept Definition, Project Evaluation and Project Review phases are described in GDG0016. Only projects under System Renewal and System Service Investment Categories follow this procedure.

4. Definitions, Abbreviations, and Acronyms

C55 – Copperleaf Asset Management Software
MILP – Mixed Integer Linear Programming

5. Project Prioritization

The Project Prioritization phase uses C55 to rank each project based on their value as calculated through the Project Evaluation phase (as defined in GDG0016- Project Evaluation Procedure). Constraints are then applied to create a detailed project list for Hydro Ottawa Executive Board approval.

5.1. Project Optimizer

The Optimizer algorithm within C55 selects the combination of projects that carry the highest overall value while fitting within specified constraints.

The Optimizer takes as inputs:

- Project or program alternatives, including budgets and value (as calculated in the Execution Phase); and
- Constraints (dependencies, time horizons, financial, resource, etc.).

The goal of the optimization is to determine the optimal portfolio of projects which maximizes the value to the organization given a set of projects/programs within a set of constraints, for example budget

envelope, and uses a Mixed Integer Linear Programming (MILP) optimization engine enabling fast computation time.

Projects classified under the 'Pole Renewal' and 'Underground Cable Renewal' programs are optimized independently from all other projects. This is done to meet the replacement levels recommended by the Asset Management Plan for each asset type.

5.2. Project List

A Preliminary Project List is created based on the Optimization process and expert knowledge of the needs and impact of the proposed projects. This list is further refined based on known expenditure and resource constraints to create the Detailed Project List.

While it is preferred that the timing for all investments are based on this optimization, mandated investments will arise, typically due to external drivers, such as regulatory or legislative mandates or health and safety concerns. When such investments occur they will have reasoning clearly documented and the impact to planned objectives will be reviewed.

The first Detailed Project List is developed based on high level estimates; this list is then sent to Project Managers for refinement of estimates. Once a refined estimate has been received for all projects on the Project List, the list goes through the Optimization process again and circulated for final feedback resulting in a revised Detailed Project List. A couple of iterations might be required before finalizing the Detailed Project List.

Program investment levels, based on the Detailed Project List, are then presented to Hydro Ottawa's Executive Management Team and Board of Directors for approval before proceeding to execution. Constraints may be re-evaluated and updated to meet objectives or adjust the level of mitigated risk.

INTERROGATORY RESPONSE - SEC-59

3-SEC-59

EXHIBIT REFERENCE:

[Ex.3-1-1]

SUBJECT AREA: Load Forecast

Question:

Please detail all changes, if any, between Hydro Ottawa's proposed load forecast methodology and that filed in its 2015-2020 application.

RESPONSE:

Minor changes were made to model specifications, such as changes to the estimation period to include additional years of data and monthly binaries.

The most significant change from the 2015-2020 methodology is that the forecast is a true bottom-up forecast. The prior methodology used a top-down approach in which all rate class model results were calibrated to a top-level system purchase model. This approach was chosen due to issues with the underlying class-level billing data, resulting in poor model statistics.

Since the 2016-2020 filling, improvements to the class-level billing data have resulted in significant improvement to the model statistics, alleviating the need to calibrate to a purchase model. The purchase forecast is now a summation of the rate classes, adjusted for line losses.

INTERROGATORY RESPONSE - SEC-60

3-SEC-60

EXHIBIT REFERENCE:

[Ex.3-2-1]

SUBJECT AREA: Other Revenue

Question:

Please update Appendix 2-H to include 2019 actuals.

RESPONSE:

Please see UPDATED Attachment 3-2-1(A): Appendix 2-H - Other Operating Revenue, as submitted on May 5, 2020.

INTERROGATORY RESPONSE - SEC-61

4-SEC-61

EXHIBIT REFERENCE:

[Ex.4-1-1, p.4-5]

SUBJECT AREA: OM&A

Question:

Please provide details regarding the adjustments made by Hydro Ottawa's Executive Management Team. Please provide a copy of the budget that was provided to the Executive Management Team.

RESPONSE:

For a summary of the budget adjustments made by Hydro Ottawa's Executive Management Team, please refer to the response to part (b) of interrogatory OEB-140. For a copy of the budget that was provided to the Executive Management Team, please see the response to part (a) of interrogatory OEB-140.

INTERROGATORY RESPONSE - SEC-62

4-SEC-62

EXHIBIT REFERENCE:

[Ex4-1-4, p.40; Ex.2-4-3, p.327]

SUBJECT AREA: OM&A

Question:

Please explain how an increase or decrease in the cost of power impacts Hydro Ottawa's IT costs.

RESPONSE:

An increase or decrease in the cost of power does not impact Hydro Ottawa's IT costs.

Hydro Ottawa notes that the cost of power is not mentioned on the pages referenced.

INTERROGATORY RESPONSE - SEC-63

4-SEC-63

EXHIBIT REFERENCE:

[Ex.4-1-5, Attachment A, p.3-4]

SUBJECT AREA: Compensation

Question:

With respect to incentive pay:

a) [p.4, Table 1] Please update to include 2019 actual information.

b) For eligible employees, what is the maximum amount of incentive based pay they are eligible to receive? If the amount differs based on employee level, please explain.

c) For each year between 2016 and 2021, please provide the actual percentage of incentive-based pay received or forecast to be received (provided on the same basis as your response to part b).

RESPONSE:

a) Please refer to the updated version of Table 1 in UPDATED Attachment 4-1-5(A): Employee Compensation Strategy.

b) Table A below provides the minimum, target and maximum percentages of incentive-based pay for each level of eligible employees.

The higher the level, the more at-risk pay, given the greater accountability and responsibility for the achievement of goals and supporting priorities, as set out in the

annual Corporate Performance Scorecards that underpin the utility's Strategic Direction.

Table A – Minimum and Maximum Percentages of Incentive-Based Pay

	Minimum	Target	Maximum
Executive	0%	30%	45%
Director	0%	20%	30%
Senior Manager	0%	10%	15%

c) Table B provides the average actual and forecast percentage of incentive-based pay received or forecast to be received from 2016-2021.

Table B – 2016-2021 Actual and Forecast Percentages of Incentive-Based Pay

	Historical				Bridge	Test
	2016	2017	2018	2019	2020	2021
Executive	36.6%	34.2%	33.0%	34.2%	33.0%	33.0%
Director	22.0%	22.6%	22.4%	19.5%	21.6%	21.6%
Senior Manager	10.6%	10.5%	10.7%	9.2%	10.6%	10.6%

INTERROGATORY RESPONSE - SEC-64

4-SEC-64

EXHIBIT REFERENCE:

[Ex.4-1-5, Attachment A, p.4]

SUBJECT AREA: Compensation

Question:

For the purposes of the forecast 2021 budget, what assumptions has Hydro Ottawa made with respect to the period (April 1, 2021-December 31, 2021) that is after the expiry of the current Hydro Ottawa-IBEW collective agreement?

RESPONSE:

Hydro Ottawa has used an assumption similar to the non-compensation related inflation rate, as noted in section 2.6 of UPDATED Exhibit 4-1-3: Operations, Maintenance and Administration Program Costs.

INTERROGATORY RESPONSE - SEC-65

4-SEC-65

EXHIBIT REFERENCE:

[Ex-4-1-5, Attachment C]

SUBJECT AREA: Compensation

Question:

Please provide a revised version of Appendix 2-K that includes the following:

a) 2019 actuals.

b) Forecast 2022-2025 period (This is required as Hydro Ottawa is not proposing a formulaic adjustment to years 2-5 of the Custom IR term for compensation costs recovered through capital).

c) A breakdown of Non-Management into two sub-categories, i) Union, and ii) Non-Union.

d) 2 additional rows that identify total compensation amounts allocated to capital and OM&A.

RESPONSE:

a) For 2019 actuals, please see UPDATED Attachment 4-1-5(C): Appendix 2-K - Employee Costs.

b) Consistent with a Custom IR approach, Hydro Ottawa escalated the 2021 OM&A budget by 2.51% for the years 2022-2025. OM&A includes employee compensation and, as

such, the 2022-2025 employee costs are not determinable.

c) For a version of Appendix 2-K that breaks down non-management into two categories, please see Attachment OEB-142(A): Updated Appendix 2-K - Employee Costs.

d) For a version of Appendix 2-K that includes compensation allocated to capital and OM&A, please see Attachment OEB-142(A): Updated Appendix 2-K - Employee Costs.

INTERROGATORY RESPONSE - SEC-66

4-SEC-66

EXHIBIT REFERENCE:

[Ex.4-2-1, p.5]

SUBJECT AREA: Shared Services and Corporate Cost Allocation

Question:

Please update Table 3 to show 2019 actuals.

RESPONSE:

Table A below is an updated version of Table 3 as it appears in Exhibit 4-2-1: Shared Services and Corporate Cost Allocation. Table A shows 2019 actual costs for the provision of Hydro Ottawa shared corporate services to its affiliated companies.

A breakdown of the services provided and associated costs is available in UPDATED Attachment 3-2-1(B): Appendix 2-N - Shared Services and Corporate Cost Allocation.

Table A – Summary of Shared Corporate Services Provided by Hydro Ottawa

Provided By	Provided To	Historical				Bridge	Test
		2016	2017	2018	2019	2020	2021
Hydro Ottawa	Holding Company	$861,944	$686,995	$1,081,985	$1,174,613	$1,450,389	$1,486,649
Hydro Ottawa	Energy Ottawa	$1,200,720	$2,618,407	$2,714,742	$1,411,512	$1,669,891	$1,711,638
Hydro Ottawa	Envari	$0	$0	$0	$1,248,470	$1,562,625	$1,601,691
Hydro Ottawa	CDM	$503,511	$618,278	$652,941	$409,917	$189,243	$34,738
TOTAL		**$2,566,176**	**$3,923,680**	**$4,449,668**	**$4,244,512**	**$4,872,148**	**$4,834,716**

INTERROGATORY RESPONSE - SEC-67

5-SEC-67

EXHIBIT REFERENCE:

[Ex.5-1-1, p.7, 10]

SUBJECT AREA: Cost of Capital

Question:

Please provide an updated version of Tables 2 and 4 with the most recent available forecast information.

RESPONSE:

Please see the response to interrogatory OEB-151 for updated versions of Tables 2 and 4 with the most recent available forecast information.

INTERROGATORY RESPONSE - SEC-68

5-SEC-68

EXHIBIT REFERENCE:

[Ex.5-1-1, p.10]

SUBJECT AREA: Cost of Capital

Question:

Please provide a table that shows what the ROE forecast would have been for each year between 2015 and 2020 based on inputs from the December 2014 Consensus Forecast.

RESPONSE:

The Consensus Long-Term Forecasts are published semi-annually in the April and October editions. To provide the requested forecast, the October 2014 edition provided in Attachment SEC-68(A): October 2014 Long-Term Consensus Forecasts was used.

Table A below shows what the Return On Equity ("ROE") forecast would have been for each year between 2015 and 2020, based on inputs from the October 2014 Long-Term Consensus Forecasts:

Table A – 2015-2020 Forecast ROE

(Based on October 2014 Long-Term Consensus Forecasts)

	2015	2016	2017	2018	2019	2020
Long Canada Bond Forecast ("LCBF")						
Consensus Forecast[1] (@ December 31)	3.0%[2]	3.6%	4.1%	4.3%	4.4%	4.4%
Average for Year	2.70%	3.30%	3.85%	4.20%	4.35%	4.40%
30-Year over 10-Year Govt. Spread[3]	0.55%	0.55%	0.55%	0.55%	0.55%	0.55%
LCBF	**3.25%**	**3.85%**	**4.40%**	**4.75%**	**4.90%**	**4.95%**
ROE Forecast						
Initial ROE (A)	**9.75%**	**9.75%**	**9.75%**	**9.75%**	**9.75%**	**9.75%**
Change in LCBF from September 2009						
LCBF	3.25%	3.85%	4.40%	4.75%	4.90%	4.95%
Base LCBF (as per OEB Cost of Capital Report)	4.25%	4.25%	4.25%	4.25%	4.25%	4.25%
Difference	(1.00)%	(0.40)%	0.15%	0.50%	0.65%	0.70%
Difference X 0.5 (B)	**(0.50)%**	**(0.20)%**	**0.08%**	**0.25%**	**0.33%**	**0.35%**
Change in A-rated Utility Bond Yield Spread from September 2009						
A-rated Utility Bond Yield Spread[4]	1.43%	1.43%	1.43%	1.43%	1.43%	1.43%
Base A-rated Utility Bond Yield Spread (as per OEB Cost of Capital Report)	1.42%	1.42%	1.42%	1.42%	1.42%	1.42%
Difference	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Difference X 0.5 (C)	**0.01%**	**0.01%**	**0.01%**	**0.01%**	**0.01%**	**0.01%**
FORECAST ROE (A+B+C)	**9.26%**	**9.56%**	**9.84%**	**10.01%**	**10.09%**	**10.11%**

[1] Please see Attachment SEC-68(A): October 2014 Long-Term Consensus Forecasts.
[2] As of the end of October 2015.
[3] As per Hydro Ottawa's *2016-2020 Custom Incentive Rate-Setting Application*, EB-2015-0004, Exhibit E, Tab 1, Schedule 1.
[4] This represents the average spread (Jan. 2010 - October 2014) Cdn Util. "A" Bond (Bloomberg: C29530Y) over GoC 30s.

INTERROGATORY RESPONSE - SEC-69

8-SEC-69

EXHIBIT REFERENCE:

[Ex.8]

SUBJECT AREA: Rate Design

Question:

Please provide a table that shows for each year between 2011 and 2025, and for each rate class, Hydro Ottawa's approved (2011-2020) and forecast (2021-2025) fixed and variable base distribution rate.

RESPONSE:

Please see Tables A and B below for Hydro Ottawa's approved 2011-2020 fixed and variable distribution rates.

Please refer to UPDATED Exhibit 8-1-1: Fixed/Variable Proportion, Tables 4 and 5 for Hydro Ottawa's forecasted fixed and variable distribution rates for 2021-2025.

Table A – Hydro Ottawa's Approved Fixed Distribution Charges (2011-2020)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential	$8.54	$9.32	$9.42	$9.55	$9.67	$12.96	$16.60	$20.51	$24.29	$27.79
GS<50kW	$14.76	$16.11	$16.28	$16.51	$16.72	$17.23	$17.89	$18.60	$19.07	$19.32
GS 50 to 1,499kW	$251.21	$251.21	$253.92	$257.47	$260.82	$200.00	$200.00	$200.00	$200.00	$200.00
GS 1,500 to 4,999 kW	$4,039.33	$4,039.33	$4,082.95	$4,140.11	$4,193.93	$4,193.93	$4,193.93	$4,193.93	$4,193.93	$4,193.93
Large Use	$14,669.82	$14,669.82	$14,828.25	$15,035.85	$15,231.32	$15,231.32	$15,231.32	$15,231.32	$15,231.32	$15,231.32
USL	$4.04	$4.26	$4.31	$4.37	$4.43	$4.42	$4.60	$4.83	$5.00	$5.09
Standby Power	$108.02	$117.90	$119.17	$120.84	$122.41	$126.36	$132.38	$138.53	$142.75	$145.13
Sentinel Lighting	$1.89	$2.52	$2.55	$2.59	$2.62	$2.98	$3.04	$3.25	$3.28	$3.17
Street Lighting	$0.49	$0.54	$0.55	$0.56	$0.57	$0.75	$0.80	$0.85	$0.89	$0.91

Table B – Hydro Ottawa's Approved Variable Distribution Charges (2011-2020)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential	$0.0207	$0.0226	$0.0228	$0.0231	$0.0234	$0.0193	$0.0151	$0.0105	$0.0054	$0.0000
GS<50kW	$0.0185	$0.0202	$0.0204	$0.0207	$0.0210	$0.0216	$0.0227	$0.0238	$0.0246	$0.0250
GS 50 to 1,499kW	$3.0380	$3.4376	$3.4747	$3.5233	$3.5691	$4.0706	$4.3245	$4.5851	$4.7680	$4.8760
GS 1,500 to 4,999 kW	$2.9014	$3.3601	$3.3964	$3.4439	$3.4887	$3.6541	$3.9181	$4.1834	$4.3608	$4.4562
Large Use	$2.7775	$3.1907	$3.2252	$3.2704	$3.3129	$3.4742	$3.7199	$3.9710	$4.1440	$4.2422
USL	$0.0200	$0.0211	$0.0213	$0.0216	$0.0219	$0.0219	$0.0226	$0.0235	$0.0240	$0.0242
Standby Power GS 50 to 1,499 kW	$1.4416	$1.5734	$1.5904	$1.6127	$1.6337	$1.6865	$1.7669	$1.8489	$1.9052	$1.9370
Standby Power GS 1,500 to 4,999 kW	$1.3224	$1.4433	$1.4589	$1.4793	$1.4985	$1.5469	$1.6206	$1.6958	$1.7474	$1.7766
Standby Power Large Use	$1.4674	$1.6016	$1.6189	$1.6416	$1.6629	$1.7166	$1.7984	$1.8819	$1.9392	$1.9716
Sentinel Lighting	$7.2434	$9.6661	$9.7705	$9.9073	$10.0361	$11.3998	$12.2794	$13.8285	$14.6566	$14.8502
Street Lighting	$3.4563	$3.8523	$3.8939	$3.9484	$3.9997	$5.3171	$5.6501	$5.9758	$6.2053	$6.3414

INTERROGATORY RESPONSE - SEC-70

9-SEC-70

EXHIBIT REFERENCE:

[Ex.9]

SUBJECT AREA: Deferral and Variance Accounts

Question:

Please provide Hydro Ottawa's views on appropriateness of the creation of an asymmetrical variance account, to capture the revenue requirement impact of any underspending on capital (on an in-service addition basis) as the Board has approved for other Custom IRs (See EB-2017-0049, EB-2018-0165, EB-2019-0082).

RESPONSE:

To clarify, Hydro Ottawa is proposing to maintain, rather than create, an asymmetrical variance account for Capital Additions Revenue Requirement with the modification of excluding System Access. As explained in section 2.2.2 of Exhibit 9-2-1: New Deferral and Variance Accounts, this sub-account would capture underspending only. In addition, Hydro Ottawa is requesting a new symmetrical variance account for System Access Capital Additions (net of contributions), as described in section 2.2.3 of Exhibit 9-2-1: New Deferral and Variance Accounts. This sub-account would capture both overspending and underspending.

In Hydro Ottawa's view, such an approach is beneficial to both customers and the distributor. It allows the distributor to work toward its five-year plan with certainty of recovery, while providing rate stability for customers. This is beneficial for customers, as it holds capital spending levels for the five-year period. At the same time, it allows the distributor to request any additional spending to be included in future rates. This latter aspect allows the distributor to make investments in the system that it considers necessary, while foregoing return in the short-term.

This addresses customer and system needs more immediately, while ensuring that the prudency of any additional spending is reviewed in future applications.

As a final point, Hydro Ottawa observes that the Z Factor is a necessary aspect of the asymmetrical variance account, as it safeguards the electricity distributor for unanticipated material events that may occur during the five-year period.