# **Appendix A - Material Capital Projects**

# Appendix A – Material Capital Expenditure Projects

- 2 Chapter 2 of the Board's Filing Requirements for Transmission and Distribution Applications
- 3 updated July 17, 2013 (the "Chapter 2 Filing Requirements"), states that "The applicant must
- 4 provide justification for changes from year to year to its rate base, capital expenditures, OM&A
- 5 and other items above a materiality threshold. The materiality thresholds differ for each
- 6 applicant, depending on the magnitude of the revenue requirement." Horizon Utilities'
- 7 materiality threshold is computed to be 0.5% of distribution revenue requirement for distributors
- 8 with a revenue requirement greater than \$10,000,000 and less than or equal to
- 9 \$200,000,000. The materiality threshold as per the Filing Requirements is \$564,780 (0.5% of
- Horizon Utilities' distribution revenue of \$112,956,026). The Materiality Threshold that Horizon
- 11 Utilities will be using for the purpose of this section of the DSP is \$300,000.
- 12 Tables 1 and Table 2 provide a summary of the Material Capital Expenditure projects for the
- 13 2015 2019 Test Years sorted by investment category, in accordance with Section 5.4.1(d) of
- 14 the Chapter 5 Filing Requirements for Transmission and Distribution Applications Consolidated
- 15 Distribution System Plan Filing Requirements (the "Chapter 5 Filing Requirements")
- 16 The remainder of this appendix provides a description of these significant projects and activities
- 17 to be undertaken and their respective key drivers; the relationship between investments and
- 18 Horizon Utilities' objectives and targets; and the primary factors affecting the timing of material
- 19 projects within each category.

- 20 Horizon Utilities has provided detailed Material Investment Templates in Appendix G of the
- 21 DSP. These templates address Section 5.4.5.2 of the Chapter 5 Filing Requirements for each
- 22 project. Appendix A includes detailed cross-references to Appendix G throughout.

# 1 Table 1: Material Capital Expenditures: System Access and System Renewal

| Project II | O Project Name                      | 2        | 2015 Test<br>Year | 20°             | 16 Test Year |     | 2017 Test<br>Year | ľ  | 2018 Test<br>Year   | Ź  | 2019 Test<br>Year |
|------------|-------------------------------------|----------|-------------------|-----------------|--------------|-----|-------------------|----|---------------------|----|-------------------|
| Reporting  | g Basis                             |          | MIFRS             |                 | MIFRS        |     | MIFRS             |    | MIFRS               |    | MIFRS             |
|            |                                     |          |                   |                 |              |     |                   |    |                     |    |                   |
| System A   |                                     |          |                   |                 |              |     |                   |    |                     |    |                   |
| SA-1       | Customer Connections                |          | 3,686,273         | \$              | 4,031,103    | _   | 4,139,076         | _  | 4,250,289           | _  | 4,364,837         |
| SA-2       | Road Relocations                    | \$       | 2,085,651         | \$              | 2,339,675    | _   |                   | \$ |                     | \$ | 1,845,327         |
| SA-3       | Meters                              | \$       | 2,470,674         | \$              | 2,101,174    | \$  | 2,046,174         | \$ | 2,063,174           | \$ | 2,063,174         |
|            |                                     |          |                   |                 |              | _   |                   | L. |                     | _  |                   |
| System A   | ccess Total                         | - \$     | 8,242,598         | \$              | 8,471,952    | \$  | 7,896,201         | \$ | 8,091,602           | \$ | 8,273,338         |
|            |                                     |          |                   |                 |              |     |                   |    |                     |    |                   |
| System R   | enewal                              |          |                   |                 |              |     |                   |    |                     |    |                   |
|            |                                     |          |                   |                 |              |     |                   |    |                     |    |                   |
| 4kV & 8k\  | / Renewal                           |          |                   | _               |              | _   |                   | Ļ  |                     | _  |                   |
|            | Aberdeen S/S                        | \$       | -                 | \$              | -            | \$  | 2,418,000         | \$ | , ,                 | _  | 2,900,000         |
|            | Baldwin S/S                         | \$       | -                 | \$              | 4 550 000    | \$  | 4 070 000         | \$ | ,,                  | \$ | 4,403,000         |
|            | Central S/S                         | \$       | -                 | \$              | 1,556,000    | \$  | 1,876,000         | \$ | 1,652,000           | \$ | 648,000           |
|            | Grantham S/S                        | \$       | 650,000           | \$              | 2,633,000    | \$  | 1,871,000         | \$ | 13,000              | \$ | 159,000           |
|            | Highland S/S<br>John S/S            | \$<br>\$ | 1,128,000         | \$              | -            | \$  | 658,000           | \$ |                     | \$ | 0.050.000         |
| SR-1       |                                     |          | - 4 000 000       | ,               | 4 500 000    | _ + | 4 707 000         | \$ | , ,                 | \$ | 8,259,000         |
|            | Strouds S/S                         | \$       | 1,020,000         | \$              | 1,533,000    | \$  | 1,787,000         | \$ | 3,831,000           | \$ | 450,000           |
|            | Taylor S/S                          | \$       | 070.000           | \$              | 2 472 000    | \$  | -<br>-<br>-       | \$ | 26,000              | \$ | 159,000           |
|            | Vine S/S                            | \$<br>\$ | 978,000           | \$              | 2,472,000    | \$  | 5,645,000         | \$ | 13,000              | \$ | 159,000           |
|            | Welland S/S                         | \$       | 4 204 000         | \$              | 4.000.000    | \$  | 4 500 000         | \$ | 13,000<br>2,115,000 | \$ | 159,000           |
|            | Whitney S/S                         | \$       | 4,384,000         | \$              | 1,966,000    | \$  | 1,509,000         |    |                     | \$ |                   |
|            | York S/S 4kV & 8kV Renewal Subtotal |          | 8,160,000         | \$<br><b>\$</b> | 10,160,000   | \$  | 45 764 000        | \$ |                     | -  | 16,846,000        |
|            | 4KV & 6KV Reflewal Subtotal         | - P      | 0, 100,000        | Ð               | 10,100,000   | Þ   | 15,764,000        | Þ  | 15,684,000          | Þ  | 10,040,000        |
| U/G (XLP   | E) Renewal                          |          |                   |                 |              |     |                   |    |                     |    |                   |
|            | Ancaster/Flamborough/Dundas         | \$       | 2,257,000         | \$              | 1,269,000    | \$  | -                 | \$ | -                   | \$ | 2,702,000         |
|            | Hamilton Mountain                   | \$       | -                 | \$              | 1,996,000    | _   | 6,607,000         | _  | 4,641,000           | \$ |                   |
| SR-2       | St. Catharines                      | \$       | 310,000           | \$              | 1,661,000    | _   | 1,759,000         | _  | 2,835,000           | \$ |                   |
|            | Stoney Creek                        | \$       | -                 | \$              | -            | \$  | 500,000           | _  | 1,908,000           | \$ | -                 |
|            | U/G (XLPE) Renewal Subtotal         | \$       | 2,567,000         | \$              | 4,926,000    | \$  | 8,866,000         | \$ | 9,384,000           | \$ | 10,271,000        |
|            |                                     |          |                   |                 |              |     |                   |    |                     |    |                   |
| SR-3       | Reactive Renewal                    | \$       | 4,780,000         | \$              | 4,339,000    | \$  | 4,457,000         | \$ | 4,536,000           | \$ | 4,608,000         |
| SR-4       | Substation Infrastructure Renewal   | \$       | 404.000           | \$              | 472.000      | \$  | 400.000           | \$ | 491.000             | \$ | F00 000           |
| 5K-4       | Substation infrastructure Renewal   | - 3      | 464,000           | Þ               | 473,000      | Þ   | 482,000           | Þ  | 491,000             | Þ  | 500,000           |
| Other Rei  | newal                               |          |                   |                 |              |     |                   | H  |                     |    |                   |
| SR-5       | Pole Residual Replacements          | \$       | 1,226,000         | \$              | 1,262,000    | \$  | 1,297,000         | \$ | 1,333,000           | \$ | 1,369,000         |
| SR-6       | LDBS Renewal                        | \$       | 323,000           | \$              | 334,000      |     | 345,000           | \$ | 357,000             | \$ | 368,000           |
| SR-7       | Proactive TX Replacements           | \$       | 350,000           | \$              | 361,000      | _   | 373,000           | \$ | 384,000             | \$ | 395,000           |
| SR-8       | Gage TS Egress Feeder Renewal       | \$       | -                 | \$              | 4,793,000    | \$  | -                 | \$ | -                   | \$ | -                 |
| SR-9       | Rear Lot Conversion                 | \$       | -                 | \$              | 1,342,000    | \$  | 1,382,000         | \$ | 696,000             | \$ | -                 |
|            | Other Renewal Subtotal              | \$       | 1,899,000         | \$              | 8,092,000    | \$  | 3,397,000         | \$ | 2,770,000           | \$ | 2,132,000         |
|            |                                     |          |                   |                 |              |     |                   | L  |                     |    |                   |
| System R   | enewal Total                        | \$       | 17,870,000        | \$              | 27,990,000   | \$  | 32,966,000        | \$ | 32,865,000          | \$ | 34,357,000        |

# 1 Table 2: Material Capital Expenditures: System Service and General Plant

|             |  | ź  | 2015 Test  | 201 | 16 Test Year |    | 2017 Test  |    | 2018 Test  | F  | 2019 Test  |
|-------------|--|----|------------|-----|--------------|----|------------|----|------------|----|------------|
| Project ID  | Project Name                                   |    | Year       |     | io rest rear |    | Year       |    | Year       |    | Year       |
| Reporting E | Basis  |    | MIFRS      |     | MIFRS        |    | MIFRS      |    | MIFRS      |    | MIFRS      |
| System Ser  | vice   |    |            |     |              |    |            |    |            |    |            |
| SS-1        | # 6 Wire Replacement                           | \$ | 570,000    | \$  |              | \$ |            | \$ |            | \$ |            |
| SS-2        | Distribution Automation                        | \$ | 1.250.000  | \$  |              | \$ |            | \$ |            | \$ |            |
| SS-3        | Waterdown 3rd Feeder                           | \$ | 984,000    | \$  |              | \$ |            | \$ |            | \$ |            |
| SS-4        | Caroline/George Redundancy                     | \$ | 952.000    | \$  |              | \$ |            | \$ |            | \$ |            |
| SS-5        | Duct Structure - Elgin TS to King St.          | \$ | - 302,000  | \$  |              | \$ | 535.000    | \$ |            | \$ |            |
| SS-6        | East 16th and Mohawk Security Project          | \$ |            | \$  |              | \$ | -          | \$ | 324.000    | \$ |            |
| SS-7        | St. Paul Street Conductor Upgrade              | \$ |            | \$  |              | \$ | _          | \$ | 1,362,000  | \$ | _          |
| SS-8        | Grays Road                                     | \$ |            | \$  |              | \$ |            | \$ | 1,302,000  | \$ | 413,000    |
| SS-9        | Mohawk/Nebo T/S Upgrade                        | \$ |            | \$  |              | \$ |            | \$ |            | \$ | 1.000.000  |
| 00-9        | Monawk/Nebo i/o opgrade                        | Ψ  |            | Ψ   |              | ¥  |            | Ψ  |            | Ψ  | 1,000,000  |
| System Ser  | vice Total                                     | \$ | 3,756,000  | \$  | -            | \$ | 535,000    | \$ | 1,686,000  | \$ | 1,413,000  |
| General Pla | ant  |    |            |     |              |    |            |    |            |    |            |
|             |  |    |            |     |              |    |            |    |            |    |            |
|             | Systems Technology ("IST")                     | Ļ  |            | _   |              |    |            | Ļ  |            | _  |            |
| GP-1        | Annual Corporate Computer Replacement          | \$ | 319,000    | \$  | 324,000      | \$ | 353,000    | \$ | 361,200    | \$ | 361,200    |
| GP-2        | IFS ERP Upgrade                                | \$ | 1,382,600  | \$  | -            | \$ |            | \$ | 1,225,000  | \$ |            |
| GP-3        | SAN Expansion                                  | \$ | 200,000    | \$  | -            | \$ | 200,000    | \$ | -          | \$ | 300,000    |
| GP-4        | Enterprise Phone System Upgrade                | \$ | 400,000    | \$  | <u> </u>     | \$ | -          | \$ | -          | \$ |            |
| GP-5        | Capital Lease - IBM                            | \$ | <u> </u>   | \$  | 900,000      | \$ |            | \$ | <u> </u>   | \$ | 900,000    |
|             | IST Sub-Total                                  | \$ | 2,301,600  | \$  | 1,224,000    | \$ | 553,000    | \$ | 1,586,200  | \$ | 1,561,200  |
| Buildings   |  |    |            |     |              |    |            |    |            |    |            |
| GP-6        | Building Renovations - John and Hughson Street | \$ | 2.000.000  | \$  | 1,600,000    | \$ | 2,200,000  | \$ | 1,200,000  | \$ |            |
| GP-7        | Building Renovations - Stoney Creek            | \$ | -          | \$  | -            | \$ | -          | \$ | -          | \$ | 1.200.000  |
| GP-8        | Building Security Replacement                  | \$ | 300.000    | \$  | 200,000      | \$ | -          | \$ | -          | \$ | -          |
| GP-9        | John Street Roof Replacement                   | \$ | 900.000    | \$  | -            | \$ | -          | \$ | -          | \$ | -          |
| GP-10       | Nebo Road Emergency Backup Generator           | \$ | 300,000    | \$  | -            | \$ | -          | \$ | -          | \$ | -          |
| GP-11       | John Street Window Replacement                 | \$ | 300,000    | \$  | 300,000      | \$ | 200,000    | \$ | -          | \$ | -          |
|             | Buildings Sub-Total                            | \$ | 3,800,000  | \$  | 2,100,000    | \$ |            | \$ | 1,200,000  | \$ | 1,200,000  |
|             | 1  |    |            |     |              |    |            |    |            |    |            |
| GP-12       | Vehicle Replacement                            | \$ | 778,000    | \$  | 780,000      | \$ | 775,000    | \$ | 785,000    | \$ | 785,000    |
| GP-13       | Tools, Shop and Garage Equipment               | \$ | 555,560    | \$  | 567,600      | \$ | 508,600    | \$ | 530,600    | \$ | 580,600    |
| General Pla | ant Total                                      | \$ | 7,435,160  | \$  | 4,671,600    | \$ | 4.236.600  | \$ | 4,101,800  | \$ | 4,126,800  |
|             |  | Ė  |            |     |              | İ  | ,,         | Ė  |            |    |            |
| Total       |  | \$ | 37,303,758 | \$  | 41,133,552   | \$ | 45,633,801 | \$ | 46,744,402 | \$ | 48,170,138 |

# Multiple Year System Access Projects

#### 2 Project ID: SA-1

**Project Name: Customer Connections** 

**Driver:** System Access

**Scope:** This on-going multi-year program involves a number of projects where investment is required to enable customers to connect to Horizon Utilities' distribution system (excluding customers' contributed capital payments). Projects in this category include: installations of service wires and transformers to connect new customers; and upgraded services to the electrical distribution system. The amount of annual investment for this program is identified in

10 Table 3 below:

# **Table 3: Customer Connections Projects**

| Project Name         | 2015 Test    | 2016 Test    | 2017 Test    | 2018 Test    | 2019 Test    |
|----------------------|--------------|--------------|--------------|--------------|--------------|
|                      | Year         | Year         | Year         | Year         | Year         |
| Customer Connections | \$ 3,686,273 | \$ 4,031,103 | \$ 4,139,076 | \$ 4,250,289 | \$ 4,364,837 |

System access projects are entirely customer driven and arise as a result of customer requests to connect to Horizon Utilities' distribution system. The 2015-2019 Test Year total expenditures are therefore derived from historical levels of expenditures. The historical expenditures represent actual total annual expenditures to connect residential and small commercial customers and as such these costs are the best available predictor of future expenditures. The 2015 to 2019 Test Year investment requirements, as provided in Table 3 above, are consistent with the increasing trend in the volume of customer connection projects experienced. Over the period of 2010-2013, Horizon Utilities has experienced a 37% increase in the number of customer connection projects. Please refer to Section 3.5.3, Table 45 of the DSP for additional information.

Horizon Utilities takes all steps possible to coordinate with the City of Hamilton and the City of St. Catharines on planning for customer connections. Ultimately, system access projects are driven by decision points within the City of Hamilton and City of St. Catharines. There is a potential for actual expenditures to vary from financial plans from year to year.

**Justification of Project:** System Access projects are investments required to meet customer service obligations in accordance with the Distribution System Code ("DSC") and Horizon

- 1 Utilities' Conditions of Service. Horizon Utilities uses the economic evaluation methodology
- 2 prescribed by the DSC to determine the level, if any, of capital contributions required for each
- 3 project; with such levels incorporated into the annual capital budget. In order to meet the
- 4 requirements of the DSC and the Horizon Utilities' Conditions of Service, these investments
- 5 cannot be deferred and must proceed as planned.
- 6 Additional Information: The following projects fall under Customer Connections as defined
- 7 above and exceed Horizon Utilities' materiality threshold. They are individually identified and
- 8 justified in the Material Project Templates in Appendix G.
- 2015 Customer Connections
- 2016 Customer Connections
- 2017 Customer Connections
- 2018 Customer Connections
- 2019 Customer Connections

# 2 Project Name: Road Relocations

- 3 **Driver:** System Access
- 4 **Scope:** Projects in this category involve the relocation of Horizon Utilities' assets to support
- 5 road relocation and road reconstruction projects at the request of the City of Hamilton, the City
- 6 of St. Catharines, the Ministry of Transportation, and the Region of Niagara. The initiation and
- 7 timing of these projects are dictated by the City of Hamilton, City of St. Catharines, the Ministry
- 8 of Transportation, or the Region of Niagara. Consequently, the timing and value of investment
- 9 required by Horizon Utilities is subject to change.
- 10 The amount of annual investment required for Road Relocation projects is identified in Table 4
- 11 below:

13

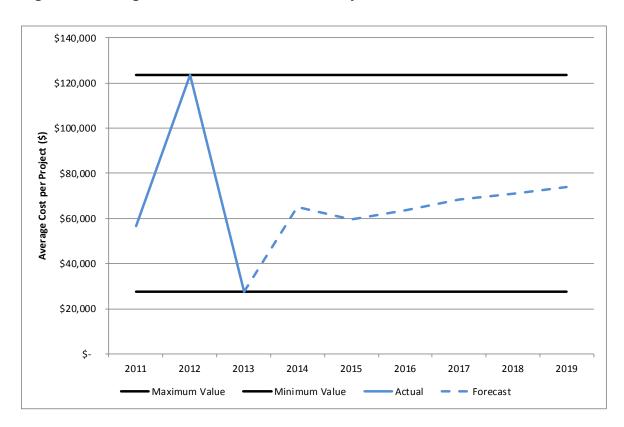
## 12 Table 4: Road Relocations Projects

| Road Relocations  | 2015 Test    | 2016 Test    | 2017 Test    | 2018 Test    | 2019 Test    |
|-------------------|--------------|--------------|--------------|--------------|--------------|
| toda itologations | Year         | Year         | Year         | Year         | Year         |
| Total             | \$ 2,085,651 | \$ 2,339,675 | \$ 1,710,951 | \$ 1,778,139 | \$ 1,845,327 |

- 14 The Road Relocation expenditure amounts identified in Table 4 represent the total investment
- 15 required for each of the Test Years. Investment levels in 2015 and 2016 are higher than the
- 16 2017 2019 Test Years in order to accommodate the Highway 5 and Highway 6 grade
- 17 separation in Waterdown.
- 18 The Cities of Hamilton and St. Catharines, the Ministry of Transportation and Region of Niagara
- 19 provide project lead times that range from six to 24 months, depending on the scope of the
- 20 project.
- 21 Justification of Project: Road relocation projects are customer initiated and Horizon Utilities is
- 22 obligated under the DSC and its Conditions of Service to perform these projects and incur
- 23 related expenditures. These investments cannot be deferred and must proceed as planned in
- 24 compliance with the DSC and the Horizon Utilities' Conditions of Service. Timelines for the
- execution of these projects are dictated by the City of Hamilton, the City of St. Catharines, the
- 26 Ministry of Transportation or the Region of Niagara. Horizon Utilities coordinates work with
- 27 these stakeholders, wherever possible, on the road relocations with planned distribution
- 28 projects. Horizon Utilities follows the Public Service Works on Highways Act, 1990 and

- associated regulations governing the recovery of costs related to road reconstruction work by collecting contributed capital for 50% of the labour; labour saving devices, and equipment rentals. Capital contributions toward the cost of all customer demand projects are collected by Horizon Utilities in accordance with the DSC and the provisions of its Conditions of Service.
  - Horizon Utilities' investment requirements for the 2015 Test Year are based upon the volume and scope of known road relocation projects. The 2016 to 2019 Test Year investment requirement is based on a forecast of 25 projects annually. 25 projects is the average annual number of road relocation projects based on the 2011 to 2013 actuals and the 2014 to 2015 forecasts. The average annual project cost used to determine the 2016 to 2019 Test Year investment requirements, relative to the maximum and minimum average annual project costs, is illustrated in Figure 1 below.

# Figure 1 - Average Annual Road Relocation Project Cost



- 1 Additional Information: The following projects are categorized as Road Relocations as defined
- 2 above and, exceed Horizon Utilities' materiality threshold. These are individually identified and
- 3 justified in Appendix G.
- 2015 Road Relocations
- 2016 Road Relocations
- 2017 Road Relocations
- 7 2018 Road Relocations
- 2019 Road Relocations

2 Project Name: Meters

3 **Driver:** System Access

4 **Scope:** This program includes the installation of Horizon Utilities' metering assets, in

- 5 compliance with Measurement Canada standards. The work includes:
- the installation of complex and commercial meters at new service locations;
- the upgrade of metering installations for expanded service requirements;
  - the inspection and replacement of defective meters;
    - the installation of new and replacement metering for residential and multi-residential metered customers; and,
- Smart Meter gatekeepers for replacement and growth.
- 12 The amount of annual investment for meters is provided in Table 5 below:

#### 13 **Table 5: Meters**

8

9

10

| Meters |              |              |              |              | 2019 Test    |
|--------|--------------|--------------|--------------|--------------|--------------|
|        | Year         | Year         | Year         | Year         | Year         |
| Total  | \$ 2,470,674 | \$ 2,101,174 | \$ 2,046,174 | \$ 2,063,174 | \$ 2,063,174 |

- 15 Meter expenditure amounts identified in Table 5 represent the total investment required for each
- 16 of the Test Years 2015 2019.
- 17 Meter investments for 2015 2019 Test Years are relatively stable for each of the years based
- 18 on a forecast of new and replacement meter installations. Horizon Utilities is forecasting 3,400
- 19 installations for residential, small commercial and multi-residential locations for growth and
- 20 replacement metering at a cost of \$1,326,000, which includes labour and materials. The
- 21 forecast also includes costs for 385 installations for the growth and replacement of complex and
- 22 commercial meters and for the replacement and growth of gatekeepers (collectors) at a cost of
- \$775,000, which includes labour and materials. Horizon Utilities is forecasting a slight
- 24 decrease in investment requirements in 2017 onwards due to the reduction in meter
- components, such as adapters, which will no longer be required for new meter installations.

- 1 **Justification:** The installation of meters is driven by customer initiated projects.
- 2 Meter replacements are completed to address meter failures and to maintain metering assets in
- 3 compliance with Measurement Canada regulations. Measurement Canada requires re-
- 4 verification of meter upon seal expiry either through compliance sampling or full re-verification
- 5 programs.
- 6 These investments cannot be deferred and must proceed as planned to meet customer
- 7 requirements and maintain regulatory compliance.
- 8 Investments in meters are forecasted primarily through the review of required compliance
- 9 sampling to comply with Measurement Canada regulations, metering requirements to support
- 10 new connections and conversion of multi-residential buildings, metering installation
- 11 requirements to support the Smart Metering Implementation Plan, and forecasted incremental
- 12 growth.
- 13 Additional Information: The following projects are categorized as Meters as defined above
- 14 and exceed Horizon Utilities' materiality threshold. They are individually identified and justified
- in Appendix G.
- 16 2015 Meters
- 17 2016 Meters
- 18 2017 Meters
- 19 2018 Meters
- 20 2019 Meters

# 1 Multiple Year System Renewal Projects

# 2 Project ID: SR-1

# 3 Project Name: 4kV and 8kV Renewal Program

**Driver:** System Renewal

**Scope:** The 4kV and 8kV Renewal Program is the primary program to renew Horizon Utilities' oldest distribution assets. Projects generated as part of this program involve the conversion of all existing 4kV and 8kV distribution assets to either 13.8kV or 27.6kV. Conversion to either 13.8kV or 27.6kV is based on the corresponding distribution voltage from transmission connected supply points depending on the operating area. The prioritization of areas is fully described in the 4kV and 8kV Plan provided in Appendix F of the DSP. The 4kV and 8kV Renewal Program is performed in areas defined by the municipal substation serving the area. Projects with durations of several years are required to renew these assets within the operating area served by each municipal substation. The corresponding substation asset will be decommissioned once the distribution assets are converted to the higher voltage. The schedule for the 4kV and 8kV projects in the 2015 to 2019 Test Years is provided in Table 6 below.

#### 16 Table 6: 4kV and 8kV Renewal Plan

| 4kV and 8kV Renewal Program | 2015 Test<br>Year | 2016 Test<br>Year | 2017 Test<br>Year | 2018 Test<br>Year | 2019 Test<br>Year |
|-----------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Aberdeen S/S                | \$0               | \$0               | \$2,418,000       | \$2,643,000       | \$2,900,000       |
| Baldwin S/S                 | \$0               | \$0               | \$0               | \$1,788,000       | \$4,403,000       |
| Central S/S                 | \$0               | \$1,556,000       | \$1,876,000       | \$1,652,000       | \$648,000         |
| Grantham S/S                | \$650,000         | \$2,633,000       | \$1,871,000       | \$13,000          | \$159,000         |
| Highland S/S                | \$1,128,000       | \$0               | \$658,000         | \$0               | \$0               |
| John S/S                    | \$0               | \$0               | \$0               | \$2,516,000       | \$8,259,000       |
| Strouds S/S                 | \$1,020,000       | \$1,533,000       | \$1,787,000       | \$3,831,000       | \$0               |
| Taylor S/S                  | \$0               | \$0               | \$0               | \$26,000          | \$159,000         |
| Vine S/S                    | \$978,000         | \$2,472,000       | \$5,645,000       | \$13,000          | \$159,000         |
| Welland S/S                 | \$0               | \$0               | \$0               | \$13,000          | \$159,000         |
| Whitney S/S                 | \$4,384,000       | \$1,966,000       | \$1,509,000       | \$2,115,000       | \$0               |
| York S/S                    | \$0               | \$0               | \$0               | \$1,074,000       | \$0               |
| 4kV & 8kV Renewal Total     | \$8,160,000       | \$10,160,000      | \$15,764,000      | \$15,684,000      | \$16,846,000      |

- 1 The operating areas serviced by the substations identified in Table 6 above are:
- St. Catharines Grantham, Taylor, Vine, and Welland substations;
- Dundas Baldwin, Highland, John, and York substations;
- Hamilton West Strouds and Whitney substations;
- Hamilton Downtown Aberdeen and Central substations.

### 6 Justification of Project:

#### 7 Project Identification

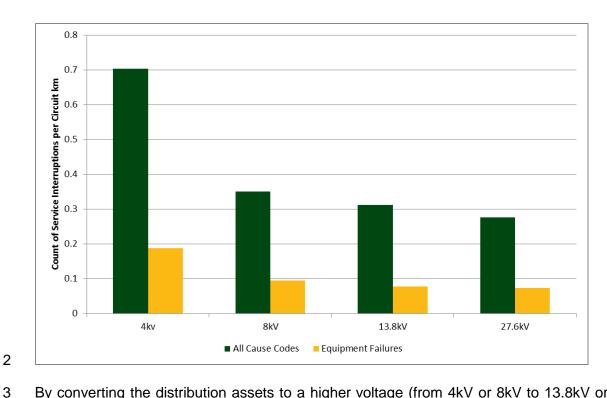
- 8 The selection and prioritization of these areas for renewal is either driven by substation asset
- 9 health (St. Catharines, Hamilton West, and Hamilton Downtown operating areas) or by the
- 10 health of the distribution system and operational constraints (Dundas operating area). The York
- 11 substation distribution assets, located in the Dundas operating area, do not interconnect with
- 12 any other assets and therefore have no back-up.
- Horizon Utilities currently serves 75,000 customers with its 4kV and 8kV distribution systems.
- 14 Horizon Utilities has 28 municipal substations which convert the electricity from the Hydro One
- 15 supplied voltage of 13.8kV or 27.6kV to the distribution voltage of 4kV or 8kV, in order to serve
- 16 these customers. The 4kV and 8kV distribution system and the associated substation assets
- 17 are among the oldest of Horizon Utilities' assets.
- 18 It is necessary to renew both the distribution assets and the substation assets, due to the
- 19 condition and age of the assets as described in the Kinectrics' Asset Condition Assessment
- 20 ("ACA") provided in Appendix B of the DSP. Horizon Utilities had two options to renew these
- 21 assets:
- i. Convert the 4kV and 8kV distribution system to a higher voltage by:
- a. Converting the distribution system to 13.8kV or 27.6kV while renewing the
- 24 distribution assets. Customers could be serviced directly from 13.8kV or 27.6kV
- 25 distribution assets and there is no incremental cost to renew at the higher voltage
- 26 level;

- b. Investing in a limited number of substation assets to support the 4kV and 8kV
   system while the long-term 4kV and 8kV Renewal Program is being implemented; and
  - c. Decommissioning the substation assets when the voltage conversions are completed. By utilizing distribution pole top transformers instead of the substation transformers, capital investment to renew substations will be avoided.
  - ii. Maintain the 4kV and 8kV distribution systems which requires:
    - a. The renewal of all substation assets at the current voltage; and
    - b. The renewal of the distribution assets at the current voltage

Horizon Utilities chose to convert the 4kV and 8kV distribution system to a higher voltage to avoid the cost of the investment in the renewal of the substations. The proposed investments in the 4kV and 8kV Renewal Program will allow nine substations to be decommissioned between 2015 and 2019. The decommissioning of these nine substations will result in the avoided capital substation renewal investment of \$22,500,000. Regardless if the area is converted from 4kV or 8 kV to a higher voltage, the fundamental fact is that the distribution assets (the poles and wires) need to be replaced because they have reached their end-of-life.

The assets at end of life can be illustrated through two key measurements: the volume of conductor having a Health Index of "very poor" or "poor"; and the rate of service interruptions experienced by customers served by the 4kV distribution system. The 4kV distribution system contains 82% (over 200km) of the total overhead conductor in Horizon Utilities' distribution system with a health index of poor or very poor. Customers serviced by 4kV distribution system experience a disproportionally high outage rate when compared to the other distribution systems. As illustrated in Figure 2 below, the 4kV distribution system experienced 225% and 254% more outages per circuit km than the 13.8kV and 27.6kV distribution systems respectively for outages caused by all cause codes over the four year period from 2010 to 2013. When considering only outages caused by equipment failures over this same period, the 4kV distribution system experienced 240% and 256% more outages per circuit km than the 13.8kV and 27.6kV distribution systems respectively.

# Figure 2 – Service Interruptions per Circuit km



By converting the distribution assets to a higher voltage (from 4kV or 8kV to 13.8kV or 27.6kV respectively) the substation asset (i.e. transformer, switchgear, breakers, relays, and building enclosure) does not need to be renewed; and as stated earlier this results in a more streamlined distribution system with a net economic benefit of \$22,500,000, the value of the substation assets for the nine locations.

The total avoided substation renewal investment over the remaining 35 years of the plan is \$70,000,000 for all 28 substations. The consequence of not executing the conversions within the 40-year timeframe is that substation assets reaching end-of-life prior to being decommissioned will require unavoidable renewal investment to maintain service to those customers who are still served by the lower voltage system. The timing of the conversion of assets to the higher voltage in the 4kV and 8kV Renewal Program is such that the conversion is completed prior to the substation assets reaching end-of-life and otherwise requiring investment. Once the distribution assets are renewed, the substation assets are decommissioned.

The 4kV and 8kV Renewal Program is the primary vehicle to address the renewal of the oldest distribution assets in Horizon Utilities' service territory. The Kinectrics ACA provided the Health Index for 22 asset groups. For further details on the Kinectrics ACA, please refer to Appendix B

- 1 of the DSP. Fifteen of these asset groups have an unacceptable Health Index
- 2 distribution. Horizon Utilities defines an unacceptable Health Index distribution as:
- at least 20% of the assets within the group have a Health Index of either "very poor" or
  "poor"; or
- the assets within the group, which have a "very poor" or "poor" health index, require a significant five year investment (greater than \$5,000,000).
- 7 Horizon Utilities' 4kV and 8kV Renewal Program addresses the renewal of assets in seven of
- 8 these fifteen asset groups. The seven asset groups are:
- Wood poles;
- Overhead conductors (primary);
- Overhead conductors (secondary);
- Overhead conductors (service);
- Pole mounted transformers;
- Substation switchgear; and
- Substation circuit breakers.

#### 16 Impact of Failures

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#### St. Catharines Operating Area

The three substations (Vine, Welland, and Grantham; Taylor is not in service, however has not yet been decommissioned) within the St. Catharines' operating area service a total of 4,000 customers and were constructed between 1959 and 1965. These substations are in poor health and require renewal. The overall substation Health Index for Vine, Welland and Grantham substations is 57%, 59%, 58%, respectively, as identified in the 4kV and 8kV Renewal Program included in Appendix F of the DSP. There is limited back-up between these substations. The loss of the Grantham or Vine substations would result in 900 and 1,100 customers respectively being without service for several days, at a minimum. Restoration of power to these customers would require the costly and unplanned emergency construction of new distribution assets all the while customers are without service. This situation is untenable and must be rectified as soon as possible.

- 1 The 4kV distribution assets in St. Catharines are underperforming, subjecting customers served
- 2 by this system to a higher level of service interruptions than the remaining customers in St.
- 3 Catharines. The SAIDI for these customers is 28% worse than for the customers served by the
- 4 13.8kV system in St. Catharines and 100% worse than Horizon Utilities' corporate target.
- 5 Please reference Section 2.2.2 of the DSP for additional information.

#### **Dundas Operating Area**

- 7 The four substations (Highland, Baldwin, John, and York) within the Dundas operating area
- 8 service 3,000 customers. These substations are all single substations (i.e., they each have one
- 9 power transformer and switchgear) with no allowance for a contingency event. Any transformer
- or switchgear failure would lead to the compete loss of the substation and would necessitate the
- 11 transfer of load to neighbouring stations.
- 12 The switchgear at the Highland substation is 44 years old, with an effective age of 58 years old
- 13 as determined by Kinectrics. The "effective age" is different from the chronological age in that it
- 14 is based on the asset's condition and the stresses that have been applied to it over the life of
- 15 the asset. Kinectrics' evaluation found that these switchgears had a high probability of failure
- within one to three years. Switchgear failure will result in the complete loss of the substation.
- 17 Failure of the Highland substation will necessitate the transfer of load to the John substation.
- 18 This will result in John substation operating in excess of capacity. Furthermore, system
- 19 operating analysis indicates that, due to the loading conditions, many customers will experience
- 20 an under-voltage condition, referred to as "brownout", that if sustained will damage customer-
- 21 owned equipment, as well as cause outages.
- 22 The failure of any of the Highland, Baldwin and John substations will result in a load transfer to,
- 23 and overload of, a neighbouring back-up station; thereby increasing the risk of failure of the
- 24 back-up station. This cascading effect is highly likely and could lead to multiple failure points,
- 25 causing over 1,000 customers to be without service for lengthy periods. The scenario below
- 26 outlines a realistic chain of events that highlights the importance of commencing with the
- 27 conversion of 4kV assets in the Dundas Area.
- 28 Scenario: Highland Substation ("Highland") experiences a transformer or switchgear failure.
- 29 748 customers are without power. The following steps are required to transfer load and restore
- 30 power.

- 1 Step 1: Transfer Highland Feeder 1 ("F1") and F3 to Highland F2 power is still out.
- 2 Step 2: Off load John F1 to Baldwin F1 power is still out

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- The John F1 is the only back up for the Highland feeders. The capacity of the John F1 feeder cannot carry this entire load (600 amps of total load on a feeder limit of 530 amps). The overload on the John F1 feeder will cause subsequent failures of feeder conductors and equipment at John Substation.
- 7 Step 3: Transfer Highland F2 to John F1 All customers back on.
- Customers have been off for approximately 4 hours
  - Low voltage will be experienced by approximately 187 customers, which could result in further outages and claims for damaged customer equipment
    - At this point John F1 is carrying three times the normal load and Baldwin F1 is carrying double the normal load. Risk of failure of equipment at John or Baldwin is now increased due to increased loading of station and distribution equipment.
- 14 Step 4: Remedy the equipment failure at Highland:
  - For a switchgear failure: There is no spare equipment to remedy this situation and a new solution would have to be engineered. This could take many weeks to many months.
  - For a transformer failure: The only spare power transformer for all four substations in Dundas is located at York Substation. In order to remove this spare transformer, York needs to be taken offline which would result in 400 customers out for twelve hours while this work is completed. It would take an additional 24 hours to remove the old transformer and re-install the spare from York at Highland.
- This scenario exhausts all contingencies available, and a failure of any equipment at John or Baldwin will result in large scale power outages until equipment can be repaired or replaced.
- York substation does not have connections to the Highland, Baldwin and John substations and therefore the load cannot be transferred in the event of a failure. Loss of this substation will leave the 400 customers served by this substation stranded without power for an extended period.

- 1 The distribution assets in the Dundas operating area are in poor health and have significant
- 2 operating constraints. This area has numerous radial feeds without backup. The Dundas
- 3 operating area also contains 25% of the 4kV Cross-linked Polyethylene ("XLPE") cable. The
- 4 4kV XLPE cable is in poor health with 38% of the assets having a Health Index of either 'very
- 5 poor' or 'poor'. The renewal of the assets in this area has the additional benefits of renewing
- 6 the underground XLPE cable and allowing for the replacement of the radial feeders with a loop-
- 7 fed system. A loop-fed system has two sources of supply which provides switching options to
- 8 restore power more quickly. The underground XLPE Renewal Program is discussed in further
- 9 detail in Section 3.5.3 of the DSP.
- 10 The substations in the Dundas operating area are all single stations which require the transfer of
- 11 the total substation load in the event of failure. This attribute, combined with the operational
- 12 constraints and lack of backup at the distribution level, result in a high risk of sustained outages
- 13 (greater than four hours) to a large number of customers.

#### **Hamilton West Operating Area**

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- 15 The two substations within this operating area service a total of 5,400 customers and provide
- backup for each other. The switchgear at these stations have a Health Index of 'very poor' as
- 17 identified in the Substation Asset Condition Assessment ("SACA") and confirmed by the
- 18 Kinectrics' ACA. The switch gear at the Strouds and Whitney substations are 44 and 46 years
- 19 old, with an effective age, as determined by Kinectrics, of 57 and 56 years old, respectively.
- 20 Kinectrics identified that both substations' switchgear had a high probability of failure within one
- 21 to three years. Switchgear failure will result in the complete loss of the substation. A loss of
- 22 both substations would result in an outage that would affect all 5,400 customers. These
- 23 customers would be without power until the substation assets were repaired. Horizon Utilities
- 24 does not maintain spare parts for all substation assets. The time required to procure
- 25 replacement parts, if not obsolete and still available, would be several months.

#### **Hamilton Downtown Operating Area**

- 27 The two substations within this operating area are Aberdeen and Central. These substations
- 28 service a total of 7,400 customers. The overall Station Health Index for Aberdeen and Central
- 29 substations is 53% and 56% respectively, as identified in the 4kV and 8kV Renewal Program
- 30 filed as Appendix F of the DSP. The switchgear at the Aberdeen substation is 40 years old;
- 31 Kinectrics determined its effective age is 54 years old. Kinectrics analysis determined that this

- 1 switchgear has a high risk of failure within five years. Aberdeen substation, which services
- 2 2,600 customers, has inadequate backup for all feeders. The failure of the switchgear at this
- 3 substation will leave customers without power or subject them to rotating blackouts.
- 4 The Central substation has ten feeders; six of which are obsolete, oil-filled breakers at end-of-
- 5 life. The Health Index for these breakers is "very poor" and Kinectrics that this switchgear has a
- 6 high risk of failure within three years. Two of the six feeders are radial feeders with no backup.
- 7 Failure of the breakers for these feeders would result in the loss of service for over 50
- 8 commercial customers in downtown Hamilton for a minimum of several hours to several days.
- 9 Central substation has limited interconnection with other substations. The loss of the entire
- 10 substation would affect all 3,100 customers who would be out of power until the substation
- 11 assets were repaired. Repair and restoration of a failed substation can take months. Horizon
- 12 Utilities does not maintain spare parts for all substation assets. The time required to procure
- replacement parts, if not obsolete and still available, would be months.
- 14 In summary, the investment in the 4kV and 8kV Renewal Program is necessary to address the
- 15 risk of imminent asset failures and prolonged customer outages.
- 16 Additional Information: The following projects within the 4kV and 8kV Renewal Program
- 17 exceed Horizon Utilities' materiality threshold and are individually identified and further justified
- 18 in Appendix G:
- HI-F3 Renewal Governor's Road West of Pirie Drive:
- ST-F7 Renewal Part 1;
- WH-F3 Renewal:
- WH-F3 Rear Lot:
- GR-F4 Renewal:
- VE-F5 Renewal;
- CE-F4 Renewal Hunter Street/Stinson St;
- ST-F7 Renewal Part 2
- WH-F5 Renewal Main St. W;
- GR-F1 Renewal South of Facer St
- GR-F2 West of Vine Av
- VE-F1 Renewal Queenston St;
- VE-F5 West of Haynes Ave;
- AB-F5 Renewal Dundurn St;
- CE-F5 Renewal Forest Ave.;
- HI-F2 Renewal conversion to 2D7X;
- ST-F2 & ST-F6 Renewal;

- WH-F6 Ewen St;
- VE-F1 Renewal North of Queenston St;
- VE-F3 Renewal
- VE-F4 Renewal Welland Ave and North St;
- GR-F2 East of Vine Ave;
- AB-F2 & AB-F4 Renewal Aberdeen East;
- BD-F1 Renewal Cross St;
- 6 CE-F10 Renewal John St. S;
- JN-F1 Renewal;
- ST-F3 & ST-F4 Renewal;
- WH-F6 Renewal Whitney Ave;
- YK-F1 York Rd Renewal;
- AB-F2 Renewal Bold St;
- BD-F1 Renewal Alma St.;
- BD-F2 Renewal;
- CE-F4 Renewal Freeman PI;
- JN-F1 Renewal;
- 18 JN-F2 Renewal;

# 2 Project: Underground XLPE Cable Renewal Program

3 **Driver**: System Renewal

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Scope: This multi-year program involves the necessary renewal of Underground ("U/G") XLPE primary cable. Annual projects are determined using the combined analysis of XLPE cable asset condition assessment studies with XLPE cable failure data and the resulting service

8 interruptions to customers.

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10 This is a multi-year program with several projects forecast for each year. The amount of annual

investment is provided in Table 7 below:

# 12 Table 7: XLPE Cable Renewal Program Investment

| Project Name                | 2  | 2015 Test<br>Year | 2  | 2016 Test<br>Year | 2  | 2017 Test<br>Year |    | 2018 Test<br>Year |    | 2019 Test<br>Year |
|-----------------------------|----|-------------------|----|-------------------|----|-------------------|----|-------------------|----|-------------------|
| Ancaster/Flamborough/Dundas | \$ | 2,257,000         | \$ | 1,269,000         | \$ | -                 | \$ | -                 | \$ | 2,702,000         |
| Hamilton Mountain           | \$ | -                 | \$ | 1,996,000         | \$ | 6,607,000         | \$ | 4,641,000         | \$ | 3,473,000         |
| St. Catharines              | \$ | 310,000           | \$ | 1,661,000         | \$ | 1,759,000         | \$ | 2,835,000         | \$ | 4,096,000         |
| Stoney Creek                | \$ | -                 | \$ | -                 | \$ | 500,000           | \$ | 1,908,000         | \$ | -                 |
| U/G (XLPE) Renewal Subtotal | \$ | 2,567,000         | \$ | 4,926,000         | \$ | 8,866,000         | \$ | 9,384,000         | \$ | 10,271,000        |

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### 14 Justification of Project:

- Justification for the increase in XLPE cable renewal expenditures in the 2015 to 2019 Test Years stems from the following factors:
- The current volume of assets with a Heath Index of either 'poor' or 'very poor';
- The forecasted Health Index distribution at 2013 investment levels will result in unacceptable levels of further deterioration of the health of this category; and
  - Impact of underground cable failures on customers.

#### 21 Current Health Index

- As depicted in Section 2.2.3, Figure 63 of the DSP, 29% of the total length of XLPE primary cable has a Health Index of either 'poor' or 'very poor'. The percentage of cable in poor health,
- 24 combined with the high volume of installed cable, results in XLPE primary cable having the

- 1 highest investment requirements. Total investments of \$172,742,000 over twenty years and
- 2 \$54,684,000 over the next five years are required to renew the XLPE primary cable identified by
- 3 the Kinectrics ACA as flagged-for-action (i.e. having a high probability of failure).

#### Forecasted Health Index

Maintaining the XLPE cable renewal investment at 2013 levels would result in further unacceptable degradation in the Health Index distribution of this asset group as illustrated above in Figure 65 in Section 2.2.3 of the DSP. At 2013 levels of investment, the percentage of XLPE primary cable having a Health Index of either 'poor' or 'very poor' would increase from the current value of 29% to 70% or 1,400 km by 2034. The failure rates associated with this level of risk will result in a significant increase in the number of outages experienced by customers compared to current levels and increased operational and maintenance costs associated with the location of faults, restoration, and repair. Ultimately, in the absence of proactive renewal as provided in this application, customers would experience unacceptable levels of system failures and outages beyond the ability of Horizon Utilities to resolve within a reasonable timeframe as these assets continue to age and degrade. Reactive replacements will also be considerably more costly than the forecast expenditure that has been submitted in this Application.

# Impact of Underground Cable Failures

An analysis of all service interruptions caused by material or equipment failure reveals that 50% of such are due to failures of underground cable and equipment. Of the service interruptions caused by underground cable and equipment, 88% are caused by XLPE cable and associated equipment, with the remaining 12% attributable to paper insulated lead covered ("PILC") cable and equipment. Failures of underground distribution assets have represented approximately 16% of the total customer minutes in the 2010 to 2013 time period when major events are excluded 1. It is reasonable to expect that the negative impact on customers will increase, as the Health Index of this asset group declines.

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<sup>&</sup>lt;sup>1</sup> April 2011 windstorm, July 2013 windstorm and December 2013 ice storm

#### Project Identification

- 2 While the Kinectrics ACA informed the annual investment requirements in this Application,
- 3 operational performance analysis (failure rates, location, and identification of worst performing
- 4 feeders) are the primary drivers in the project selection process.
- 5 The Ancaster/Dundas/Flamborough investments address end-of-life 4kV XLPE primary cable.
- 6 XLPE renewal projects provide renewal of end-of-life XLPE primary cable but also support the
- 7 4kV and 8kV Renewal Program. This renewal will involve the conversion of the
- 8 Ancaster/Dundas/Flamborough operating area to the 27.6kV distribution system because that is
- 9 the Hydro One distribution supply voltage in this operating area.
- 10 Expenditures in the Hamilton Mountain, St. Catharines, and Stoney Creek areas are driven by
- 11 poor reliability and the impact of underground distribution system failures in each area.
- 12 Approximately 50% of the total XLPE renewal investment will be for the Hamilton Mountain area
- 13 as the 13.8kV distribution system in this area contains 33% of the total XLPE cable in Horizon
- 14 Utilities' distribution system and receives over 50% of the customer outage minutes due to
- 15 equipment failures. Projects within each area are identified and selected through equipment
- 16 failure analysis and the resulting impact upon customers from the failure of underground
- 17 distribution assets.
- 18 Additional Information: The following projects within the XLPE Renewal Program exceed
- 19 Horizon Utilities' materiality threshold and are individually identified and justified in the following
- 20 Material Project Templates in Appendix G.
- HI-F3 Renewal U/G Bridlewood subdivision:
- GR-F4 Renewal Charleen Circle U/G:
- 2015 St. Catharines XLPE Renewal;
- 2016 Hamilton Mountain XLPE Renewal:
- HI-F1 Renewal U/G Conversion to 2D14X
- GR-F2 Roehampton URD;
- 2016 St. Catharines XLPE Renewal;
- 2017 Hamilton Mountain XLPE Renewal;
- 2017 Stoney Creek XLPE Renewal;
- 2017 St. Catharines XLPE Renewal:
- 2018 Hamilton Mountain XLPE Renewal;
- 2018 Stoney Creek XLPE Renewal;
- 2018 St. Catharines XLPE Renewal;
- 2019 Hamilton Mountain XLPE Renewal:

- 1 2019 Stoney Creek XLPE Renewal;
- 2 2019 St. Catharines XLPE Renewal;
- YK-F2 Watson's Lane XLPE Renewal.

### 2 **Project Name: Reactive Renewal**

- 3 **Driver:** System Renewal
- 4 **Scope:** Unplanned failures of overhead and underground system components are corrected in
- 5 a reactive manner to restore service to customers as a result of the following:
- Immediate replacement of failed assets that have resulted in a service interruption;
- Urgent replacements identified through trouble calls from customers or other external
   parties where failure of the assets is imminent;
- Urgent and necessary replacement of assets resulting from inspections, and/or in
   response to findings pursuant to the Electrical Safety Authority ("ESA") due diligence
   inspections;
- Urgent and necessary replacement of assets identified through Horizon Utilities'
   inspection and maintenance programs; and
- Projects required to address customer power quality issues.
- 15 Reactive renewal expenditure is required to support the restoration of service to the customer.
- 16 The 2015-2019 forecast values are based on a three year rolling average, and would equate to,
- on average, the replacement of 234 poles and 112 transformers and the associated conductors
- 18 and hardware each year.

#### 19 **Table 8: Reactive Renewal**

| Project Name     | 2  | 2015 Test<br>Year | 2  | 2016 Test<br>Year | 2  | 2017 Test<br>Year | 2  | 2018 Test<br>Year | 2  | 2019 Test<br>Year |
|------------------|----|-------------------|----|-------------------|----|-------------------|----|-------------------|----|-------------------|
| Reactive Renewal | \$ | 4,780,000         | \$ | 4,339,000         | \$ | 4,457,000         | \$ | 4,536,000         | \$ | 4,608,000         |

#### 21 Justification of Projects:

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Horizon Utilities experiences a large volume of equipment failures annually resulting in service interruption to customers. Capital investment is required to repair the distribution system and restore service to customers where equipment has failed. These expenditures are reactive in nature originating from over 3,500 customer outage calls/year on average into Horizon Utilities'

- 1 System Control Centre. In addition, Horizon Utilities completes 140 projects on average each
- 2 year to address safety and power quality concerns.
- 3 Investment is required annually to restore service to affected customers; address power quality;
- 4 and to address other urgent issues identified through Horizon Utilities' inspection programs or
- 5 reported by external organizations (e.g. ESA). Failure to perform these investments will result in
- 6 the inability to address:
- safety concerns identified by ESA and Horizon Utilities inspection programs; and
- power quality concerns identified by Horizon Utilities' customers.
- 9 Additional Information: The following projects within the Reactive Renewal Plan exceed
- 10 Horizon Utilities' materiality threshold and are individually identified and justified in the following
- 11 Material Project Templates in Appendix G.
- 2015 Enhancements
- 2015 OH/UG Reactive Renewal
- 2016 Enhancements
- 2016 OH/UG Reactive Renewal
- 2017 Enhancements
- 2017 OH/UG Reactive Renewal (Hamilton)
- 2018 Enhancements
- 2018 OH/UG Reactive Renewal
- 2019 Enhancements
- 2019 OH/UG Reactive Renewal

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2 Project Name: Substation Infrastructure Renewal

3 **Driver:** System Renewal

4 **Scope**: This program involves the ongoing renewal of substation infrastructure throughout

5 Horizon Utilities' service territory. Horizon Utilities performs annual substation maintenance and

inspection programs. Through these inspections, Horizon Utilities identifies a number of

required investments for the continued safe and reliable operation of Horizon Utilities'

8 substations. Investments within this program include battery replacements, Supervisory Control

9 and Data Acquisition ("SCADA") and communication upgrades, and grounding improvements.

10 This is a multi-year project with the following annual investment requirements:

#### 11 Table 9: Substation Infrastructure Renewal

| Project Name                      | 20 | 015 Test<br>Year | 201 | 6 Test Year | 2  | 017 Test<br>Year | 2  | 018 Test<br>Year | 20 | 19 Test<br>Year |
|-----------------------------------|----|------------------|-----|-------------|----|------------------|----|------------------|----|-----------------|
| Substation Infrastructure Renewal | \$ | 464,000          | \$  | 473,000     | 65 | 482,000          | \$ | 491,000          | \$ | 500,000         |

**Justification of Project**: This program is required for the ongoing safe and reliable operation of Horizon Utilities' municipal substations, and other miscellaneous investments in the electrical and supervisory infrastructure. The 4kV and 8kV Renewal Program is structured to decommission Horizon Utilities' 28 substations over the next 34 years. There is no investment in the renewal of the major electrical assets (power transformers, switchgear and breakers) forecasted for the 2015 to 2019 Test Years. The investments provided above are required to maintain the ancillary substation assets in safe working order. Substation investment requirements are identified though preventative maintenance programs performed on both routine maintenance cycles and monthly inspections. Safety related investments include installation of eye wash stations, end-of-life replacements of batteries and chargers for the emergency backup breaker operation circuits, and the replacement of end-of-life or obsolete station service transformers. These transformers are required to light and heat the substation and are the main source of power for the substation equipment. Miscellaneous investments include reactive replacement of relays, communication equipment and protection instrument transformers. Investments are required to address both electrical assets within the substation (e.g. replacement of switchgear components and instrument transformers), and ancillary equipment (e.g. SCADA, communication equipment, or backup batteries). These are critical to the continued safe and reliable operation of the substation. Failure to perform these required

- 1 investments could lead to premature failure of substation components resulting in service
- 2 interruptions and increased operating or reactive capital expenditures.

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#### 2 Project Name: Pole Residual Replacements

3 **Driver:** System Renewal

- 4 **Scope:** This project involves the replacement of wood poles that are determined to have a high
- 5 probability of imminent failure through Horizon Utilities' maintenance and inspection programs.
- 6 This is a multi-year project with the following annual investment requirements:

# 7 Table 10: Pole Residual Replacement

| Project Name               | 2  | 015 Test<br>Year | 2  | 2016 Test<br>Year | 2  | 017 Test<br>Year | 2  | 2018 Test<br>Year | 2  | 2019 Test<br>Year |
|----------------------------|----|------------------|----|-------------------|----|------------------|----|-------------------|----|-------------------|
| Pole Residual Replacements | \$ | 1,226,000        | \$ | 1,262,000         | 55 | 1,297,000        | \$ | 1,333,000         | \$ | 1,369,000         |

- 9 **Justification of Project:** Wood pole replacement requirements are primarily identified through
- the following programs representing best utility practice:
- 11 Wood Pole Testing Program: Horizon Utilities annually tests the structural integrity of wood
- 12 poles through non-destructive testing procedures. All wood poles are tested on a seven year
- 13 cycle. Failed poles as identified through visual, sound and resistograph testing are scheduled
- 14 for replacement. Further details for this program can be found in Section 3.1.3 of the DSP.
- 15 Visual Inspection Program: Horizon Utilities performs a visual inspection of the entire
- 16 distribution system on a three year interval to identify defective poles at end-of-life due to major
- 17 rot and decay, cracks to ground line, hollow hearts (centres) and significant insect (e.g.
- carpenter ants or bees) damage or infestation. Such poles are identified as urgent replacements
- and are replaced in the same year.
- 20 Individual pole replacements that are necessary as a result of identification under either of these
- 21 programs must be undertaken immediately, as a failure of a pole typically results in a service
- 22 interruption and often presents a hazard to public safety. Wood poles are a foundational piece
- 23 of the distribution infrastructure and, as such, it is prudent to replace poles based on proactive
- testing rather than on failure-based replacement approaches.
- 25 Additional Information: The following projects fall under Pole Residual Replacement as
- 26 defined above and exceed Horizon Utilities' materiality threshold and are individually identified
- 27 and justified in the Material Project Templates in Appendix G.

- 1 2015 Pole Residual Replacements
- 2 2016 Pole Residual Replacements
- 2017 Pole Residual Replacements
- 4 2018 Pole Residual Replacements
- 2019 Pole Residual Replacements

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# 2 Project Name: Load Break Disconnect Switches ("LBDS") Renewal

3 **Driver:** System Renewal

Scope: This project involves the replacement of LBDS found to be either inoperable or beyond economic repair (where the cost of maintenance exceeds the cost of replacing the unit) as found through Horizon Utilities' maintenance and inspection programs. Such switches will be replaced with automated switches for this program. This is a multi-year program based on

sixteen replacements per year. The annual investment requirements are as follows:

#### Table 11: LBDS Renewal

2018 Test 2015 Test 2016 Test 2017 Test 2019 Test **Project Name** Year Year Year Year Year 323,000 \$ 334,000 \$ 345,000 \$ 357,000 \$ LDBS Renewal \$ 368,000

Justification of Project: During routine inspection and maintenance of LBDS, a small percentage of switches are found to be inoperable or require extensive maintenance that would exceed the cost of simply replacing the unit. LBDS are critical devices for the operation of the distribution system and are installed at key operating points (e.g. feeder tie points, feeder sectionalizing). Unplanned failures of these devices would impact Horizon Utilities' ability to restore power, resulting in extended outages. Annual costs are based on historical levels and Horizon Utilities expects this to remain fairly constant as the overall Health Index for LBDS is good (the percentage of this asset class with a "poor" or "very poor" Health Index is 20%).

- **Additional Information:** The following projects within the LBDS Program exceed Horizon Utilities' materiality threshold and are individually identified and justified in the Material Project Templates in Appendix G.
- 2015 LBDS Replacement
  - 2016 LBDS Replacement
  - 2017 LBDS Replacement
- 2018 LBDS Replacement
- 2019 LBDS Replacement

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# 2 Project Name: Proactive Transformer Replacement

3 **Driver:** System Renewal

- 4 Scope: This project was established to proactively replace distribution transformers as
- 5 required. Renewal of distribution transformers has previously been completed reactively upon
- 6 failure or proactively when included in the 4kV & 8KV Renewal or XLPE Cable Renewal
- 7 Programs. There are instances where proactive replacement of transformers not identified
- 8 through the above programs above is required. This is a multi-year project, based on 25
- 9 replacements per year. The investment requirements are as follows:

### 10 Table 12: Proactive Transformer Replacement

| Project Name              | 20 | )15 Test<br>Year | 2  | 016 Test<br>Year | 20 | 017 Test<br>Year | 20 | 18 Test<br>Year | 20 | 19 Test<br>Year |
|---------------------------|----|------------------|----|------------------|----|------------------|----|-----------------|----|-----------------|
| Proactive TX Replacements | \$ | 350,000          | \$ | 361,000          | \$ | 373,000          | \$ | 384,000         | \$ | 395,000         |

- 12 **Justification of Project:** Proactive transformer replacements are identified through Horizon
- 13 Utilities' visual inspection programs and Polychlorinated Biphenyls ("PCB") testing programs.
- 14 Proactive replacement criteria include:
  - Transformers that have visibly deteriorated and have a high risk of imminent failure,
    - Obsolete Transformers that do not have replacement units in inventory and, in a reactive replacement scenario, the customer(s) may be subject to extended outage duration.
    - Transformers that have visible oil leaks, and
- Transformers that have been identified through testing as containing PCBs.
- 20 These criteria were selected due to the level of associated risk. Transformers with visible oil
- 21 leaks or containing PCBs represent a significant environmental risk. All oil spills must be
- 22 tracked, reported, and the oil reclaimed where possible. Obsolete transformers, where a
- replacement is not available in inventory, represent a risk of prolonged service interruption upon
- 24 failure and are replaced to reduce the risk of outage to the customer. Details regarding the
- 25 Proactive Transformer Replacement Program are found in Section 3.1.3 of the DSP.

- 1 Additional Information: The following projects within the Proactive Transformer Replacement
- 2 Program exceed Horizon Utilities' materiality threshold and are individually identified and
- 3 justified in the Material Project Templates in Appendix G.
- 2015 Proactive Transformer Replacement
- 2016 Proactive Transformer Replacement
- 2017 Proactive Transformer Replacement
- 7 2018 Proactive Transformer Replacement
- 2019 Proactive Transformer Replacement

### 2 Project Name: Rear Lot Conversion

3 **Driver:** System Renewal

- 4 **Scope:** This project involves the replacement of rear lot overhead distribution assets.
- 5 Replacement options include relocating primary only, or relocating all assets to either overhead
- 6 or underground in the front lot. Options are dependent on many factors (e.g. presence of trees
- 7 and availability of room in the road allowance) and are assessed on a case by case basis.
- 8 This project will involve the renewal of end-of-life rear lot overhead distribution assets serviced
- 9 at 13.8kV and therefore are not included in the 4kV and 8kV renewal programs. This is a multi-
- 10 year project with the following investment requirements:

#### 11 Table 13: Rear Lot Conversion

| Project Name        | 2015 Test<br>Year | 2016 Test<br>Year | 2017 Test<br>Year | 2018 Test<br>Year | 2019 Test<br>Year |
|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Rear Lot Conversion | \$ -              | \$ 1,342,000      | \$ 1,382,000      | \$ 696,000        | \$ -              |

#### Justification of Project:

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Horizon Utilities has identified several residential areas serviced by a rear lot overhead distribution system. Horizon Utilities has experienced a dramatic increase in reliability issues surrounding rear lot distribution systems due to falling customer-owned trees and lack of access for utility crews to repair or replace equipment. The poles are a mix of wood and concrete that, by design, are unsafe to scale to repair; and replacement of poles and equipment is labour intensive and requires specialized equipment to access rear yards. Access is restrictive and as such restoration time is significantly extended in the event of a failure. These identified assets are nearing or beyond end-of-life and should be replaced. In the past several years, storm related failures in these areas have increased, with corresponding long outage durations (in excess of 24 hours). These outages have precipitated the need to create a multi-year program to address the residential areas serviced by a rear lot distribution system.

- 1 Additional Information: The following projects within the Rear Lot Conversion Program exceed
- 2 Horizon Utilities' materiality threshold and are further detailed in Appendix G.
- 2016 Rear Lot Conversion
- 4 2017 Rear Lot Conversion
- 2018 Rear Lot Conversion

### 1 Multiple Year General Plant Projects

# 2 Project ID: GP-1

### 3 Project Name: Annual Corporate Computer Replacement Program

4 **Driver:** General Plant

5 This initiative is part of an ongoing business requirement to replace end user 6 computers. Personal Computers ("PCs") are considered a strategic asset because they are 7 Horizon Utilities' primary productivity tool for many employees. Horizon Utilities' has 8 streamlined its PC lifecycle management processes to: ensure maintenance and delivery of 9 services to customers; provide the necessary tools to maintain and improve staff productivity; 10 cost-effectively manage total cost of PC ownership; and support investments in new 11 applications, infrastructure, and business capabilities. Horizon Utilities' utilizes a PC refresh 12 cycle of 36 months. Approximately one third of Horizon Utilities' PCs are replaced annually 13 (~150 PCs/year).

14 This is a multi-year project with the following annual investment requirements:

# 15 **Table 14: Annual Corporate Computer Replacement**

|    | Project Name                          | 20 | 15 Test<br>Year | 2016 | Test Year | 2  | 017 Test<br>Year | 20 | )18 Test<br>Year | 20 | 19 Test<br>Year |
|----|---------------------------------------|----|-----------------|------|-----------|----|------------------|----|------------------|----|-----------------|
| 16 | Annual Corporate Computer Replacement | \$ | 319,000         | \$   | 324,000   | \$ | 353,000          | \$ | 361,200          | \$ | 361,200         |

### 17 Justification of Project:

- 18 Horizon Utilities' corporate computer replacement program is based on achieving a balance
- 19 between: maintaining and improving customer service levels; managing capital expenditure; and
- 20 maintaining effective Information Technology ("IT") operations and support.
- 21 A three year replacement schedule is utilized for laptop and tablet computers. Over 50% of
- Horizon Utilities' personal computers are laptops and tablets. These are replaced every three
- 23 years to manage the impact on worker productivity related to hardware performance and
- 24 hardware failures. Many of these tablets and laptops are used by staff working in harsh
- 25 operating environments outside the office, or by staff utilizing applications that require increased
- power to process large volumes of data, such as, Geospatial Information Systems ("GIS"),
- 27 Planning and Scheduling, business analytics, and Budgeting and Forecasting.

- 1 A three year replacement schedule is utilized for desktop computers. The majority of desktop
- 2 computers are used in business critical operations such as the customer call centre and
- 3 Network Operations, where staff downtime can directly impact customers. It is critical for
- 4 Network Operations to be able to respond quickly to electrical system issues; response time and
- 5 customer safety could be compromised if computer hardware is not functioning properly.
- 6 In recent years Horizon Utilities' has invested heavily in new systems such as GIS, Outage
- 7 Management System ("OMS"), and Budgeting and Forecasting. These systems are data and
- 8 processing intensive, requiring increased computational power.
- 9 Additional Information: The following projects within the Annual Corporate Computer
- 10 Replacement exceed Horizon Utilities' materiality threshold and are individually identified and
- 11 justified in the Material Project Templates in Appendix G.
- 2015 Annual Corporate Computer Replacement

- 2016 Annual Corporate Computer Replacement
- 2017 Annual Corporate Computer Replacement
- 2018 Annual Corporate Computer Replacement
- 2019 Annual Corporate Computer Replacement

- 2 Project Name: Industrial and Financial Systems ("IFS") Enterprise Resource Planning
- 3 ("ERP") Upgrade
- 4 **Driver:** General Plant
- 5 **Scope:** This 2015 initiative is the third and final phase of an enterprise-wide project that
- 6 commenced in 2013 to upgrade Horizon Utilities' ERP system from IFS version 7.3 to version
- 7 8.1 and to enhance the ERP system. Details related to Phase 1 and 2 are provided in
- 8 Exhibit 2, Tab 6, Schedule 1.

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- 10 This phase involves the redesign and optimization of existing business processes using new
- 11 features and functions available in IFS version 8.1, which are expected to deliver operational
- 12 efficiencies and staff productivity improvements. Processes being optimized or implemented
- 13 include:
  - Optimization of Accounts Payable processing to: automate invoice 3-way matching to
- reduce manual effort and processing time;;
- Implementation and optimization of purchase order processes to: improve purchase
- 17 authorization process; automate supplier contract document routing process; optimize
- server-based document storage; and, streamline project inventory process to improve
- 19 purchase order process;
- Implement IFS mobile work order functionality to automate processing and eliminate
- 21 duplicate data entry;
- Simplification of standardized labour rates and Activity Based Costing ("ABC") reporting;
- Implementation to the IFS Eco-Footprint Module to reduce manual effort and cost of
- 24 Global Reporting Initiative ("GRI") and Sustainment auditing and reporting;
  - Implementation of IFS mobile applications to improve authorization processes for
- 26 purchase requisitions, purchase orders, travel expenses, and time entry;
- Implementation of IFS dashboards and analysis to reduce the manual effort required to
- 28 extract and compile data outside of IFS; and
- Streamline processes for OEB reporting and reduce manual effort.

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- 31 The 2015 investment of this multi-year initiative is \$1,382,600 consisting of \$750,000 of
- 32 capitalized internal labour and \$632,600 in software add-ons and third-party consulting support.

- Justification of Project: The estimated annual benefit for this phase is approximately \$703,500 and is detailed in Exhibit 4, Tab 3, Schedule 4. These benefits will be realized in the following areas:
  - Staff productivity improvements This phase of the project is estimated to deliver approximately 6,965 hours of annual staff productivity improvements with an estimated value of \$603,500. These improvements will be realized through reductions in transaction processing times and automation of manual tasks.
  - Cost Reductions and Cost Avoidance For some processes it is estimated that process changes will deliver reduction in costs related to transaction completion and elimination of fees currently being incurred. Removal of these modifications will contribute to operational effectiveness by: reducing the costs of annual software maintenance fees by \$50,000 related to the modifications; avoiding future cost for annual software maintenance on modifications for which IFS will start billing if the modifications are not removed; and reduce costs related to future upgrades by eliminating the requirement to transition modifications to future software versions.

The automation of some processes will allow existing staff to process more transactions, avoiding future cost increases related to incremental headcount to support transaction volumes. The estimated annual total of these cost reductions and cost avoidance improvements is \$100,000.

- These productivity gains are part of the productivity achievements discussed in Exhibit 4, Tab 3, Schedule 4.
- Additional Information: The following project within the IFS ERP upgrade exceeds Horizon
  Utilities' materiality threshold and is individually identified and justified in the Material Project
  Templates in Appendix G.
  - 2015 IFS ERP Upgrade

# 1 Project Name: 2018 IFS ERP Upgrade

- 2 **Scope:** This is an enterprise-wide project in 2018 for the lifecycle upgrade of Horizon Utilities'
- 3 ERP system from IFS version 8.1 to the then current vendor supported version. This is a major
- 4 upgrade to the IFS ERP system which was last upgraded in 2013. This project is required to
- 5 mitigate operational risks dependent on software not supported by the vendor. This project will
- 6 be a straight migration of functionality to the most current version.
- 7 The estimated capital expenditure for this project in 2018 is \$1,225,000 with a target
- 8 implementation date of September 2018.
- 9 Justification of Project: Horizon Utilities uses IFS to manage business critical processes in
- 10 Finance, Human Resources, Supply Chain Management, Asset Management, and Engineering
- 11 Project Planning. This project is both a lifecycle upgrade and a risk mitigation project. IFS's
- 12 software development plans are to release a new major version of the system every three
- 13 years. IFS will only provide support for the two most recent versions. The application must be
- 14 upgraded in order to maintain IFS support for this system.
- 15 Horizon Utilities has scheduled this project in 2018 to manage required IT investment and
- 16 manage internal resource commitments to minimize impact on customers and business
- 17 operations. Any delay of this project would also conflict with a required major upgrade of
- 18 Horizon Utilities' CIS system, the development for which begins in 2019. Horizon Utilities would
- 19 not be able to support both an IFS upgrade and CIS upgrade concurrently.
- 20 Additional Information: The following project within the IFS ERP upgrade exceeds Horizon
- 21 Utilities' materiality threshold and is individually identified and justified in the Material Project
- 22 Templates in Appendix G.

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• 2018 IFS ERP Upgrade

- 2 Project Name: Storage Area Network ("SAN") Expansion
- 3 **Driver:** General Plant
- 4 Scope: This is a risk management and sustainment project scheduled every two years to
- 5 ensure adequate data storage capacity for Horizon Utilities at the production data centre in
- 6 Hamilton and the disaster recovery data centre in St. Catharines. The project involves the
- 7 expansion of the existing SAN in both the production and disaster recovery data centres.
- 8 This is a multi-year project with the following annual investment requirements:

## 9 Table 15: SAN Expansion

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|----|--|
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| Project Name  | 15 Test<br>Year | 2  | 016 Test<br>Year | 20 | 017 Test<br>Year | 2  | 018 Test<br>Year | 20 | )19 Test<br>Year |
|---------------|-----------------|----|------------------|----|------------------|----|------------------|----|------------------|
| SAN Expansion | \$<br>200,000   | \$ | -                | \$ | 200,000          | \$ | =                | \$ | 300,000          |

- 12 Justification of Project: This project is required to support Horizon Utilities' annual data
- 13 growth rate which, based on historical experience, exceeds 30% per annum. The data growth
- 14 rate is expected to increase during the 2015-2019 Test Years as new applications such as GIS
- and OMS are implemented.
- 16 This investment in SAN expansion will eliminate risk related to insufficient storage capacity to
- 17 support day-to-day business operations.
- 18 The risk of not proceeding with this project is that Horizon Utilities will not have enough disk
- 19 storage capacity to sustain its systems environment to meet its business requirements.
- 20 Additional Information: The following project is identified and justified in the Material Project
- 21 Templates in Appendix G:
  - Storage Area Network ("SAN") Expansion

- 2 Project Name: Capital Lease IBM (2016 and 2019)
- 3 Driver: General Plant
- 4 **Scope**: This project is the end of lease replacement of the IBM iSeries server hardware
- 5 environment used to run the Daffron Customer Information System ("CIS") which supports
- 6 Horizon Utilities' customer management and meter-to-cash processes. The hardware is a three-
- 7 year lease with planned renewals in 2016 and 2019. The environment includes a production
- 8 IBM iSeries server in Hamilton and an identical IBM iSeries server at the Disaster Recovery
- 9 Data Centre in St. Catharines.
- 10 This project has the following annual investment requirements:

# 11 Table 16: Capital Lease – IBM

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| Project Name        | 2015 Test | 2016 Test  | 2017 Test | 2018 Test | 2019 Test  |
|---------------------|-----------|------------|-----------|-----------|------------|
|                     | Year      | Year       | Year      | Year      | Year       |
| Capital Lease - IBM | \$ -      | \$ 900,000 | \$ -      | \$ -      | \$ 900,000 |

- 13 Justification of Project: The IBM iSeries hardware lease will expire December 31, 2015 and
- 14 December 31, 2018. This environment is required to maintain the continued operation of
- 15 Horizon Utilities' Daffron CIS system to ensure appropriate technology for the customer
- 16 management and meter-to-cash processes. Replacement of the IBM iSeries hardware at end-
- 17 of-life reduces the likelihood of hardware failures that could disrupt normal business operations,
- 18 impacting Horizon Utilities' ability to: read smart meters; bill customers; apply customer
- 19 payments; manage customer interactions; and manage customer work orders.
- 20 **Additional Information:** The following projects are identified and justified in the Material Project
- 21 Templates in Appendix G:
- 2016 Capital Lease IBM
- 2019 Capital Lease IBM

2 Project Name: Building Renovations – John Street

3 **Driver:** General Plant

## 4 Scope:

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5 This is a multi-year project with the following annual investment requirements:

## 6 Table 16: Building Renovations and Refurbishment

| Project Name                                  | 2015 Test    | 2016 Test    | 2017 Test    | 2018 Test    | 2019 Test |
|---|--------------|--------------|--------------|--------------|-----------|
|   | Year         | Year         | Year         | Year         | Year      |
| Building Renovations & Refurbishment Projects | \$ 2,000,000 | \$ 1,600,000 | \$ 2,200,000 | \$ 1,200,000 | \$ -      |

- 8 The 2015 scope of this multi-year project includes the renovation to a portion of the fifth floor in
- 9 an effort to consolidate all IST employees into one workspace. Additional space will also be
- 10 provided to accommodate current and future requirements for the Human Resources, Corporate
- 11 Communications, and Health and Safety employees. Space that was formerly occupied by the
- 12 Hughson substation building will be reclaimed and converted into the main corporate training
- 13 room, currently located on the fifth floor. This industrial space is more than 100 years old, and
- 14 requires full restoration including:
- the removal of hazardous materials such as asbestos and mould;
- the installation of HVAC systems;
- the installation of life and safety support systems; and
- the installation of lighting systems suitable for an office environment.
- 19 The 2016 scope of this multi-year project involves the renovation of the second floor to:
- 20 consolidate Customer Service and Conservation and Demand Management ("CDM") employees
- 21 to a single floor; improve employee security and safety; and address lighting and air quality
- 22 deficiencies.
- 23 The renovation of the sixth floor of the John Street building is planned for 2017. This floor is
- 24 virtually unchanged from its time of construction in the 1960s, with limited updates
- approximately twelve years ago. The Resource and Office Space Utilization Study, included as

- 1 Appendix J of the DSP and conducted in 2010, concluded that additional space was required at 2 the John Street building to reduce the congestion and improve the work environment. Horizon 3 Utilities reclaimed part of the 6th floor from the City of Hamilton Water Division to provide the 4 additional space required. This space has been effectively used as "swing space" to support 5 building renovation and renewal projects from 2012 to 2016. The swing space will be renovated 6 to replace much of the electrical, mechanical, lighting systems when the building projects are 7 complete. Building systems engineered and installed in the 1960s, are at end-of-life and cannot 8 support the current occupancy demand. Renovations will also include removal of all existing 9 walls, the remediation of hazard materials and expansion of the floor foot print to current space 10 requirements.
- 11 The 2018 scope of this multi-year project includes the renovation to the John Street basement 12 locker, washroom, and shower space which is largely original to the 1950s building. These end-13 of-life facilities, equipment and systems continue to fail and require constant repairs. The 14 renovation will also accommodate the size and needs of the workforce, remediate hazardous 15 materials, and replace end-of-life facilities. The project will also include renovations to the 16 public and customer entrance to improve the utilization of space and to address employee and 17 public security.
- 18 Justification of Project: Horizon Utilities has five main buildings on four properties, comprised of two adjacent head office buildings and three Service Centres. Horizon Utilities also has 28 substations; 23 of which are inside a building enclosure within the cities of Hamilton and St. Catharines. These building were constructed between 1914 and the early 1980s. The majority 22 of the office space was largely as originally built prior to renovations that commenced in 2012.
  - Building infrastructure systems are at or nearing end of life, resulting in: poor equipment performance; increased risk of system failure; poor work environments for employees; and increased health and safety risks. The original floor layouts, building systems and structures do not meet the needs of the current workforce.
- 27 In addition, operational expenditures for the maintenance and operations of the Horizon Utilities' 28 buildings are increasing year-over-year due to:
  - increased maintenance on end-of-life systems;
  - required structural repairs; and

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- additional expense to procure replacement parts for obsolete systems.
- 2 Horizon Utilities identified that a long-term building asset renewal plan was necessary and
- 3 commenced a series of studies in 2010 to:
- understand building and operational requirements;
- determine the level of required investment; and,
- prioritize and pace the prospective building renewal projects in order to balance related
   costs and customer rate implications against the risk and benefits of such projects.
- 8 The independent studies included: a Resource and Office Space Utilization Study Report
- 9 ("Space Study"), filed as Appendix J in the DSP by PRISM Partners Inc.; a Building Condition
- 10 Assessment ("BCA") by Evans Consulting Services, filed as Appendix K in the DSP; Horizon
- 11 Utilities Physical Security Report ("Security Study") filed as Appendix L in the DSP; a window
- 12 assessment for the John Street building by MMM Group Limited ("Horizon Window Study
- 13 Report") filed as Appendix M in the DSP; and a roof assessment for the John Street and
- 14 Hughson buildings by Garland Canada Inc. ("Roof Inspection Review") filed as Appendix N in
- 15 the DSP.
- 16 The studies were undertaken to aid in the development of Horizon Utilities' long-term building
- 17 renewal strategy and to assess and evaluate the following:
- the health of building infrastructure systems including heating and air ventilation
   conditions, and their risk of failure;
- office space environmental conditions;
- health and safety concerns related to poor air quality, and unsecured access points;
- continued compliance with the Ontario Building Code ("OBC") and Fire Codes;
- the structural integrity of the buildings;
- office space availability to support current and future workforce and equipment; and
- options to renovate the five existing buildings as compared to building a new centralized Horizon Utilities' office.
- 27 The buildings have not been renovated since their original construction and as such, the floor
- 28 layout and design includes large offices and work areas which do not meet the needs of the

- 1 current organization. This is creating a congested and unsafe work environment. Meeting
- 2 rooms have been used as office space to house employees from the same functional group,
- 3 reducing the availability of meeting room space. Numerous workstations have been installed
- 4 inside existing offices due to the lack of available open office space. The Space Study identified
- 5 opportunities to balance the space available to support the organization's current and future
- 6 requirements by reducing congestion and creating appropriate work flows.
- 7 Horizon Utilities' buildings are comprised primarily of: office space; common areas that are
- 8 available to all employees; and areas to support customer service, warehousing, fleet parking,
- 9 and garage spaces.
- 10 The renovation projects allow Horizon Utilities to make more effective and efficient use of
- 11 available space through:
- Rationalization of existing office spaces and creation of new office spaces to meet
- 13 operational requirements;
- Creation of necessary common spaces, including meeting rooms, washrooms, and
- 15 lunchrooms to accommodate the needs of 440 employees;
- Re-claiming under-utilized spaces; and,
- Updating security to provide for controlled access to buildings and employees.
- 18 The Space Study evaluated all five of Horizon Utilities' buildings. It determined that the office
- 19 work environment was congested and some business units were housed at multiple locations
- 20 which led to operational inefficiencies and unproductive, overcrowded work environments. The
- 21 Space Study determined that Horizon Utilities existing office space cannot support the current
- 22 requirements of the current work force.
- 23 The Space Study also identified health and safety concerns, including:
  - air quality was compromised by vehicle emissions and was at the lowest end of the
- 25 acceptable threshold range;

- certain electrical and fire and life support systems were not compliant with the current
- OBC. Any systems installed prior to the current OBC are grandfathered and may remain
- in operation with proper maintenance and regular inspections. However, these systems
- 29 had reached end-of-life and were at risk of not functioning effectively;

- 1 pedestrian work flows and vehicle traffic were in the same work areas which created 2 dangerous environments for employees and customers. 3 The Space Study identified opportunities to reclaim under-utilized space and restructure existing 4 space to resolve congested work areas and support the requirements of the current and future 5 workforce. 6 and window and roof assessments identified a number of major The BCA, 7 systems and assets that are at end-of-life and require replacements or upgrades including: the roof at the John Street and Hughson Street buildings; the John Street 8 9 building windows; and a back-up emergency generator at the Nebo Road Service Centre. 10 The planning activities of the building renovation include the following major considerations: 11 Building system demand; 12 Building occupancy demand; 13 Forecasted changes in employee headcount and office equipment requirements; 14 Building equipment and systems failure reporting; and, 15 Operational performance planning. 16 2015 Planned Building Renovations 17 Two main projects are planned for 2015 at the Head Office to address congestion, consolidate 18 work groups to improve organizational work flows and to comply with current fire codes and the 19 OBC. 20 Fifth Floor - Head Office 21 This project will: consolidate IST staff which currently reside in three different locations 22 onto one floor; and provide sufficient space for the Human Resources, Health and Safety, and Corporate Communications departments. 23 24 **Hughson Substation – Phase 2** 
  - the removal of hazardous materials such as asbestos and mould;

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industrial space is more than 100 years old, and requires full restoration including:

The project will include the reclamation of Hughson Substation building, which was an

active distribution station prior to its planned decommissioning scheduled for 2014. This

- the installation of HVAC systems;
- the installation of life and safety support systems; and
- lighting.

The space will be converted into a large training room which will become the main corporate training room for Head Office. This will reduce travel time for Head Office employees who currently travel approximately 30 minutes or 20 km from 55 John St to the Stoney Creek Service Centre Training Room. Reclamation of the industrial space represents a capital expenditure of \$1,500,000.

## 2016 Planned Building Renovations

- 10 The project planned for 2016 will focus on the second floor of the John Street building, which
- 11 remains in similar condition to that originally constructed in 1950. The project will address
- 12 employee security, safety and deficiencies related to fire and OBC codes, air quality and
- 13 lighting.

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### 14 Second Floor – Head Office

- 15 The second floor of the Head Office will be renovated to consolidate Customer Service and
- 16 CDM employees into contiguous workgroups for organizational efficiency and to improve
- 17 employee security and safety by relocating Customer Service cashiers from the area adjacent to
- 18 the customer lobby on the first floor.
- 19 The fire and life safety and electrical systems will be updated to comply with current fire codes
- and the Ontario Building Code "OBC". All Heating, Ventilation and Air Conditioning "HVAC"
- 21 components will be replaced and redirected as required to ensure air quality meets appropriate
- 22 standards.

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### 2017 Planned Building Renovations

- 24 The renovation of the sixth floor of the John Street building is planned for 2017. This floor is
- 25 virtually unchanged from its time of construction in the 1960s, with limited updates
- approximately twelve years ago.
- 27 The Space Study conducted in 2010 concluded that additional space was required at the John
- 28 Street building to reduce the congestion and improve the work environment. Horizon Utilities

reclaimed part of the 6<sup>th</sup> floor from the City of Hamilton Water Division to provide the additional space required. This space has been used, and will continue to be used, as "swing space" to support building renovation and renewals projects from 2012 to 2016. The swing space will be renovated to replace much of the electrical, mechanical, lighting systems when the building projects are complete. Building systems engineered and installed in the 1960s, are at end-of-life and cannot support the current occupancy demand. Renovations will also include removal of all existing walls, the remediation of hazard materials and expansion of the floor foot print to current space requirements.

### Sixth Floor – Head Office

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The renovation of the sixth floor, which houses members of the Executive Management Team and includes temporary swing space for re-located departments as renovation projects occur will include:

- the creation of additional office space to address organizational congestion from other floors at Head Office;
- the installation of HVAC and fire and life safety systems that are at end-of-life;
- the disposal of hazardous materials including asbestos and anticipated mould resulting from an leaking roof; and
- the creation of necessary meeting room space.

## 2018 Planned Building Renovations

The project planned for 2018 is the renovation of the basement and lobby of the Head Office building, which is largely original to the 1950s building.

### Basement / Lobby - Head Office

The project will include the following:

- renovation of the locker, washroom, and shower space which is relatively unchanged from those originally constructed the 1950's building. These facilities have leaking plumbing and are unable to accommodate the size and needs of the current workforce;
- the removal of anticipated hazardous materials and the replacement of end-of-life HVAC and fire and life safety systems; and

- renovations to the public and customer entrance to improve the utilization of space and .
  - the necessary installation of fire stops devices in walls, doors and frames which require fire rating as per Ontario Building Code.
- 6 Additional Information: The following projects within the Building Renovations and
- 7 Refurbishment John Street exceed Horizon Utilities' materiality threshold and are individually
- 8 identified and justified in the Material Project Templates in Appendix G.
- 2015 Building Renovations John Street

- 2016 Building Renovations John Street
- 2017 Building Renovations John Street
- 2018 Building Renovations John Street

| 1 Project ID: GP-8 |
|--------------------|
|--------------------|

2 Project Name: Building Security Replacement

3 Driver: General Plant

Scope: This multi-year initiative involves

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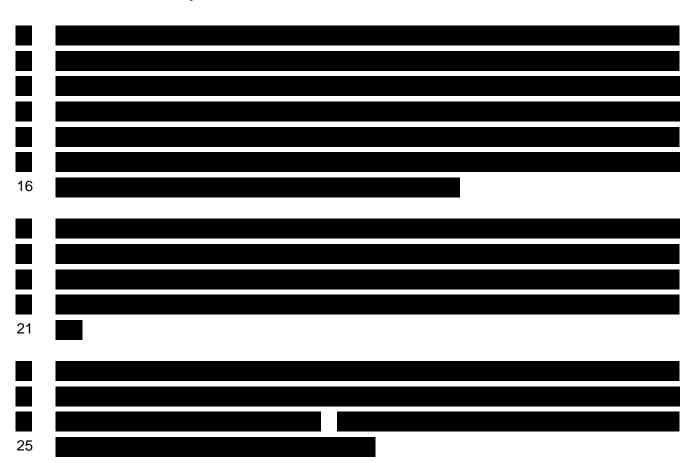
6 This is a multi-year project with the following annual investment requirements:

# 7 Table 17: Building Security Replacement

| Project Name                  | 20 | )15 Test<br>Year | 2  | 016 Test<br>Year | 20 | 017 Test<br>Year | <br>8 Test<br>∕ear | 2019 Test<br>Year |   |
|-------------------------------|----|------------------|----|------------------|----|------------------|--------------------|-------------------|---|
| Building Security Replacement | \$ | 300,000          | \$ | 200,000          | \$ | -                | \$<br>-            | \$                | - |

9 Justification of Project:

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- 1 Additional Information: The following projects within the Building Security Replacement
- 2 exceed Horizon Utilities' materiality threshold and are individually identified and justified in the
- 3 Material Project Templates in Appendix G.

- 2015 Building Security Replacement
- 2016 Building Security Replacement

2 Project Name: John Street Window Replacement

3 **Driver:** General Plant

## 4 Scope:

- 5 This multi-year project involves replacement of the windows at the John Street location. The
- 6 windows, installed in 1994, have reached end-of-life and require replacement in order to reduce
- 7 energy costs and to maintain the comfort of the employees from a climate and noise
- 8 perspective.
- 9 This is a multi-year project with the following annual investment requirements:

### 10 Table 18: John Street Window Replacement

| Project Name                   | 15 Test<br>Year | 20 | )16 Test<br>Year | 20 | 017 Test<br>Year | 20 | 18 Test<br>Year | 19 Test<br>Year |
|--------------------------------|-----------------|----|------------------|----|------------------|----|-----------------|-----------------|
| John Street Window Replacement | \$<br>300,000   | \$ | 300,000          | \$ | 200,000          | \$ | •               | \$<br>-         |

## Justification:

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- 13 The condition of the windows at the 55 John Street building was evaluated in a 2013 energy
- 14 efficiency gap assessment conducted by independent consultant MMM Group Limited. MMM
- 15 Group Limited and its subsidiaries/affiliates comprise a global firm with more than 50 offices in
- 16 Canada and around the world. MMM Group is a partner of choice for major design-build and P3
- 17 transportation and building projects in Canada, the U.S. (through Lochner MMM Group), and
- 18 around the world.
- 19 The assessment was conducted using visual inspections, air leakage testing, and building
- 20 energy simulations. The testing concluded that the condition of the operable windows at the
- 21 John Street location is poor. The windows are no longer weather resistant or energy efficient
- 22 and allow cold drafts to enter the building in the winter. Heat convection during the summer
- 23 months leads to air conditioning inefficiency and additional stress on HVAC systems. The
- 24 windows collect frost on the inside in the winter which melts and damages interior walls and
- 25 carpeting. The windows, installed in 1994, have reached end-of-life and require replacement in
- order to reduce energy costs and to maintain the comfort of the employees from a climate and
- 27 noise perspective. Weather stripping was determined to be insufficient as identified through air
- 28 leakage tests.

- 1 Additional Information: The following projects within the John Street Window Replacement
- 2 exceed Horizon Utilities' materiality threshold and are individually identified and justified in the
- 3 Material Project Templates in Appendix G.
- 2015 John Street Windows Replacement
- 2016 John Street Windows Replacement
- 2017 John Street Windows Replacement

- 1 Project ID: GP-12
- 2 Project Name: Vehicle Replacement
- 3 **Driver**: General Plant

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- 4 Scope: Horizon Utilities' fleet expenditures are required to maintain vehicles and major
- 5 equipment on a sustainable basis in support of safe, reliable, and responsive customer service.
- 6 This is a multi-year project with the following annual investment requirements:

## 7 Table 19: Vehicle Replacement

|     | Project Name      | 20 | 015 Test<br>Year | 2  | 016 Test<br>Year | 20 | 017 Test<br>Year | 20 | )18 Test<br>Year | 20 | 19 Test<br>Year |
|-----|-------------------|----|------------------|----|------------------|----|------------------|----|------------------|----|-----------------|
| Vel | nicle Replacement | \$ | 778,000          | \$ | 780,000          | \$ | 775,000          | \$ | 785,000          | \$ | 785,000         |

9 The following vehicles are scheduled for replacement in the 2015 to 2019 Test Years.

## Table 20: Vehicles Scheduled for Replacement

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| Vehicle                                       | Model Year | Proposed<br>Replacement<br>Year |
|---|------------|---------------------------------|
| Unit 246 – Heavy Duty Pickup                  | 1998       | 2015                            |
| Unit 220 – Double Bucket                      | 1997       | 2015                            |
| Unit 296 – Passenger Vehicle/Cargo Van        | 2002       | 2015                            |
| Unit 292 – Low Duty Pickup                    | 2002       | 2015                            |
| Unit 380 – Low Duty Pickup                    | 2001       | 2015                            |
| Unit 234 – Passenger Vehicle/Cargo Van        | 1999       | 2015                            |
| Unit 213 - Heavy Duty Pickup                  | 2000       | 2015                            |
| Unit 298 - Heavy Duty Pickup                  | 2000       | 2016                            |
| Unit 241 – Passenger Vehicle/Cargo Van        | 1998       | 2016                            |
| Unit 248 – Knuckle Crane Truck                | 1997       | 2016                            |
| Unit 217 – Single Bucket                      | 2000       | 2016                            |
| Unit 277 – Single Bucket                      | 2000       | 2017                            |
| Unit 267 - Heavy Duty Pickup                  | 1999       | 2017                            |
| Unit 330 – Cable Pulling/Digger Derrick Truck | 2003       | 2017                            |
| Unit 293 - Heavy Duty Pickup                  | 2000       | 2017                            |
| Unit 279 - Step Van                           | 2001       | 2017                            |
| Unit 327 – Passenger Vehicle/Cargo Van        | 2002       | 2017                            |
| Unit 286 - Single Bucket                      | 2002       | 2018                            |
| Unit 287 – Single Bucket                      | 2002       | 2018                            |
| Unit 295 - Heavy Duty Pickup                  | 2003       | 2018                            |
| Unit 291 - Heavy Duty Pickup                  | 2003       | 2018                            |
| Unit 257 – Single Bucket                      | 1999       | 2019                            |
| Unit 285 – Single Bucket                      | 2002       | 2019                            |
| Unit 281 – Step Van                           | 2001       | 2019                            |

### 3 Justification of Project:

- 4 Horizon Utilities has a six year Fleet Replacement Plan which is updated annually. The plan
- 5 provides direction for the management of the fleet inventory including condition assessment,
- 6 based upon: vehicle class; vehicle specification; system requirements; regulation changes;
- 7 organizational needs; employee safety; and environmental risks.
- 8 Horizon Utilities has replacement assessment criteria for each classification of fleet assets;
- 9 specifically, light duty vehicles, heavy duty vehicles, and trailers. The assessment considers:
- 10 the general condition of the asset; its mileage; engine hours; and the years of service of the
- 11 vehicle to determine whether a vehicle should be replaced. Using the fleet asset replacement
- 12 criteria, Horizon Utilities has identified 24 light and heavy duty vehicles that require replacement
- 13 between 2015 and 2019, as identified in Table 20. Horizon Utilities is not adding any new
- vehicles or replacing any trailers during these test years.

# Table 21: Replacement Criteria

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| Fleet Class         | Replacement Assessment Criteria  |  |  |  |  |  |  |
|---------------------|--|--|--|--|--|--|--|
| Light Duty Vehicles | Assessed at 6 years and every year after, and/or high mileage (excess of 150,000 km)   |  |  |  |  |  |  |
|                     | Typical replacement schedule: 6 to 8 years   |  |  |  |  |  |  |
|                     | Assessed at 11 year service, and every year after, and/or high mileage (excess of 200,000 km)                                |  |  |  |  |  |  |
| Heavy Duty Vehicles | High engine hours (excess of 15,000 engine hours)  |  |  |  |  |  |  |
|                     | Typical replacement schedule: 16 to 19 years   |  |  |  |  |  |  |
|                     | Trailer replacement will follow the same core principles as the vehicle replacement criteria with the following differences: |  |  |  |  |  |  |
| Trailers            | i) When assessing trailer conditions, trailers will be refurbished rather than replaced                                      |  |  |  |  |  |  |
|                     | ii) When trailers cannot be refurbished due to application change or condition, trailers will be flagged for replacement     |  |  |  |  |  |  |

- 3 The replacement life for light duty and heavy duty vehicles as identified above is:
  - six to eight years for light duty vehicles. Horizon Utilities has 93 light duty vehicles, of which 45 or 48% are currently eight years and older.
  - sixteen to nineteen years for heavy duty vehicles. Horizon Utilities has 39 Heavy Duty Vehicles, of which 8 or 21% will be nineteen years or older within the next five years. In addition, some vehicles will need to be replaced prior to the end of their replacement life, because they have either exceeded 200,000km in mileage or 15,000 engine hours.
  - Operation of vehicles past their useful life results in increased expenditures related to operating and maintenance. When a vehicle requires frequent maintenance, it is unavailable for use and impacts crew work and scheduled projects. All vehicles scheduled for replacement have surpassed the replacement criteria listed above.
- Additional Information: The following projects within the Vehicle Replacement exceed Horizon
   Utilities' materiality threshold and are individually identified and justified in the Material Project
   Templates in Appendix G.

- 1 2015 Vehicle Replacement
- 2 2016 Vehicle Replacement
- 3 2017 Vehicle Replacement
- 4 2018 Vehicle Replacement
- 2019 Vehicle Replacement

## 2 Project Name: Tools, Shop and Garage Equipment

3 **Driver**: General Plant

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- 4 **Scope:** This project includes expenditures pertaining to the purchase and replacement of tools
- 5 and equipment, which are either: worn; beyond repair; or the continued use of such creates
- 6 health and safety risk. This equipment is used by various trades/technical employees at Horizon
- 7 Utilities including: Distribution System Line Trades (Line persons, Cable Splicers, Substation
- 8 Maintainers, and Labourers); Meter Technicians; Vehicle Mechanics; Facility Maintainers;
- 9 Logistics (Warehouse Staff); and engineering related positions.
- 10 Equipment can be categorized into the following groups:
  - Safety Equipment includes traffic control equipment; dielectric tools and cover up;
     rescue devices and personal protective equipment;
  - Storage Systems includes warehouse shelving and storage systems and equipment;
- Rigging and Grounding includes grips, hoists, conductor stringing equipment and cable
   pulling equipment, and grounding devices;
- Tools and Equipment includes battery-operated equipment; and hydraulic and
   mechanical tools;
  - Measurement/Test/Computing Equipment includes volt meters, gas detectors, mobile computing accessories and GPS units.
- 20 This is a multi-year project with the following annual investment requirements:

# 21 Table 22: Tools Shop and Garage Equipment

| Project Name                     | 15 Test<br>Year | 2016 | 6 Test Year | 2  | 017 Test<br>Year | 20 | 018 Test<br>Year | 20 | )19 Test<br>Year |
|----------------------------------|-----------------|------|-------------|----|------------------|----|------------------|----|------------------|
| Tools, Shop and Garage Equipment | \$<br>555,560   | \$   | 567,600     | \$ | 508,600          | \$ | 530,600          | \$ | 580,600          |

**Justification of Project**: Each year a condition assessment is conducted on the inventory of tools and equipment in use, to determine a forecast for expected replacements. Feedback from the crews that use the tools and equipment, together with feedback from the Fleet Mechanics

who maintain the tools and equipment on each vehicle, is used to establish the annual budgets. It becomes unsafe, costly and inefficient to use or maintain this type of equipment which has reached the end of its useful life.

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New tools become available on the market, on a periodic basis, that offer improved safety, ergonomics and productivity features which Horizon Utilities evaluates for use. Changes in regulations, which require a different standard of equipment, may necessitate a replacement of tools and equipment. Fall arrest equipment for example, needs to be exchanged when new standards come into effect, and any required new equipment is included in the budget.

- 11 Additional Information: The following projects within the Tools and Equipment Program
- 12 exceed Horizon Utilities materiality threshold and are individually identified and justified in the
- 13 Material Project Templates in Appendix G.
- 2015 Tools, Shop and Garage Equipment;
- 2016 Tools, Shop and Garage Equipment
- 2017 Tools, Shop and Garage Equipment
- 2018 Tools, Shop and Garage Equipment
- 2019 Tools, Shop and Garage Equipment

## 1 2015 System Service Projects

2 Project ID: SS-1

3 Project Name: #6 Wire Replacement

**Driver:** System Service

Scope: Horizon Utilities has an ongoing program to proactively replace #6 overhead primary conductor throughout its service territory. Most of the #6 Wire Replacement will be captured under the 4kV and 8kV Renewal Program. Areas with #6 wire not covered in the 4kV and 8kV Renewal Program are identified and prioritized for replacement based on: Health Index; volume of #6 wire; and the need to address operational deficiencies. The cost of each project is based

on the volume of wire and complexity of effort required for replacement.

- **Justification of Project:** Horizon Utilities will replace an aggregate of 3km of #6 wire at a cost of \$570,000 in 2015. The costs are inclusive of pole and transformer replacements which are required to meet current engineering standards. Horizon Utilities experiences a number of 'wire down' incidents annually for a variety of reasons such as pole or insulator failures and conductor failures. Investigations of these incidents indicate a higher risk associated with #6 primary conductors than other conductor types due to the following factors:
  - Solid #6 conductors have a higher probability of failure which may result in a wire down incident.
  - This small gauge solid conductor is not as durable as the current standard which provides for a multi-stranded conductor.
  - This overhead conductor is also replaced when 4kV conversion projects are completed.
- Horizon Utilities has established a program to proactively replace #6 primary conductors to address the higher risk of failure. Horizon Utilities has removed 102 km of conductor (as of July 1, 2013) from the inception of this program in 2002, through both the #6 Wire Replacement Program and the 4kV and 8kV Renewal Program. This replacement of #6 wire will continue beyond the 2019 Test Year, primarily through the 4kV and 8kV Renewal Program, as there will still be 131 km of #6 conductor in service that will require removal.

- 1 These types of projects are directly linked to ensuring public safety and are therefore non-
- 2 discretionary in nature.
- 3 Additional Information: The following project #6 Wire Replacement exceeds Horizon Utilities'
- 4 materiality threshold and are individually identified and justified in the Material Project
- 5 Templates in Appendix G.

• # 6 Wire Removal - Eastmount

# Project ID: SS-2

- 2 **Project Name: Distribution Automation**
- 3 **Driver:** System Service
- 4 **Scope:** This project involves the deployment of automated switches, reclosers and fault
- 5 indicators through Horizon Utilities' service territory as identified in Horizon Utilities' Basic GEA
- 6 Plan as submitted in Horizon Utilities 2011 Cost of Service Application (EB-2010-0131).
- An investment of \$1,250,000 is required for the deployment of distribution automation in 2015.
- 8 **Justification of Project:** The automation of the distribution system through the installation of
- 9 automated load break disconnect switches (i.e. the ability to remotely identify faulted areas and
- 10 remotely restore service through the use of remotely controlled switches) is fundamental
- 11 towards reversing the recent trend of declining reliability and increased service interruptions.
- 12 Automated switches will be installed on the poorest performing feeders and feeders with high
- 13 customer counts and long lengths. Automated switches will be installed along these feeders to
- provide the ability to sectionalize the feeder and at normal open points to allow for the load to be
- transferred to a neighbouring feeder.
- 16 Distribution automation will also mitigate the impact of service interruptions resulting from
- 17 significant weather events (i.e. the high volume of outages resulting from wind and ice storms).
- 18 Horizon Utilities worst performing feeders with the largest number of customer minutes of
- 19 outage are the highest priority for automation.
- 20 During severe storms, contractors and other utilities are often engaged when the scale of
- 21 restoration exceeds Horizon Utilities' crew capacity to deal with outages in a timely manner.
- 22 Automation allows sections of the distribution plant to be restored remotely, allowing crews to be
- 23 dispatched to other calls requiring on-site response. In this way, automation offers an
- 24 opportunity to improve service restoration and lower the costs associated with on-site
- 25 restoration.
- 26 Automation, once fully deployed throughout the distribution system, is expected to improve
- 27 reliability by 10%. Horizon Utilities' reliability is driven by a small number of large outages (1%
- 28 of outages constitute 40% of the total customer of minutes annually). Analysis of the 2013
- 29 largest impact outages (excluding the July 2013 windstorm and December 2013 ice storm)

- 1 indicated that automation would have reduced the impact of these outages by 25%. These
- 2 results, when extrapolated across all outages, would result in a reduction of 10% annually.
- 3 Additional Information: The following project, within the Distribution Automation Program,
- 4 exceeds Horizon Utilities' materiality threshold and is individually identified and justified in the
- 5 Material Project Templates in Appendix G.
  - 2015 GEA Feeder Automation

# 1 Project ID: SS-3

- 2 Project Name: Waterdown Third Feeder
- 3 **Driver:** System Service
- 4 Scope: This project involves the construction of an alternate, third feeder to improve the
- 5 security for the Waterdown express feeders 2D12X and 2D13X.
- 6 An investment of \$984,000 in 2015 is required to complete this project.
- 7 Justification of Project: The Dundas 2D12X and 2D13X feeders service the Waterdown area
- 8 and provide back-up to one another. The construction of a third feeder will address both
- 9 capacity and security issues in the Waterdown area. The two existing feeders (2D12X and
- 10 2D13X) share a common pole line from Dundas TS to the intersection of Highway 5 and
- 11 Highway 6. The section along Valley Road from York Rd to Rock Chapel Road is especially
- 12 susceptible to outages as this section ascends the Niagara Escarpment through heavy
- 13 vegetation. This poses a risk to security as pole failure or falling trees that damage the
- 14 conductors will affect both feeders and leave the 7,000 customers in Waterdown without service
- until repairs are complete. This project will construct a third feeder along an alternate route to
- 16 improve the security of the feeders servicing Waterdown. This investment must be made in
- 17 2015 as the Ministry of Transportation is redeveloping the Highway 5 and Highway 6
- 18 interchange in 2015/2016, which will require the removal of both of the existing feeders, leaving
- 19 Waterdown without service.
- 20 This project will address security issues in the Waterdown area, as well as provide capacity for
- 21 the projected load growth in Waterdown.
- 22 Additional Information: The following project within the Watertown Third Feeder Program
- 23 exceeds Horizon Utilities' materiality threshold and is individually identified and justified in the
- 24 Material Project Templates in Appendix G.
- Waterdown 3<sup>rd</sup> Feeder Upgrade York Road

- 1 Project ID: SS-4
- 2 Project Name: Caroline/George Redundancy
- 3 **Driver:** System Service
- 4 **Scope:** This project will create an alternative backup supply to the redeveloped Hamilton
- 5 downtown in the Caroline and George St. area.
- 6 This project requires an investment of \$952,000 in 2015.
- 7 **Justification of Project:** Existing assets are not able to provide full redundancy and therefore
- 8 an additional circuit must be installed to provide proper backup to these customers. Other
- 9 alternatives such as transfer of load to adjacent feeders have been reviewed but failed
- 10 preliminary assessment. This project must be completed in 2015 as the forecasted load growth
- will exceed the existing backup supply in 2016. Customers in this newly redeveloped section of
- 12 downtown Hamilton would not be adequately serviced should a failure to the primary service
- 13 occur.

- 14 Additional Information: The following project within the Caroline/George Program exceeds
- Horizon Utilities materiality threshold and is individually identified and justified in the Material
- 16 Project Templates in Appendix G.
- Caroline and George Backup

- 1 2015 General Plant Projects
- 2 Project ID: GP-4
- 3 Project Name: Enterprise Phone System Upgrade
- 4 **Driver:** General Plant
- 5 **Scope:** This 2015 project is a planned lifecycle upgrade of Horizon Utilities' Cisco phone
- 6 system and call center management software installed in 2010. This project involves
- 7 replacement of the phone system and call centre software in Hamilton and the redundant
- 8 backup phone system in St. Catharines. The two phone systems are configured to provide
- 9 automatic failover in the event of loss of service at either site.
- An investment of \$400,000 is required in 2015 to complete this project.
- 11 Justification of Project: This planned lifecycle replacement of the Horizon Utilities' phone
- 12 system is required to ensure critical call centre software, and the associated supporting
- hardware, are at vendor supported versions. The Horizon Utilities' phone system is a critical
- 14 infrastructure component that is the primary method of communication with customers and as
- such, needs to be at vendor supported levels to maintain optimum customer service levels. The
- vendor will cease to support the current phone hardware system in 2016.
- 17 Additional Information: The following project Enterprise Phone System Upgrade exceeds
- 18 Horizon Utilities' materiality threshold and is individually identified and justified in the Material
- 19 Project Templates in Appendix G.

22

• Enterprise Phone System Upgrade

- 2 Project Name: John and Hughson Street Roof Replacement
- 3 **Driver:** General Plant
- 4 Scope: The rooves at the John Street and Hughson Street buildings have surpassed end-of-life
- 5 and as per a roof assessment conducted by Garland Canada Inc. ("Roof Inspection Review")
- 6 filed as Appendix N in the DSP, require replacement. The roof was last replaced in 1999 and,
- 7 despite annual maintenance, leaks have caused damage to the floors below.
- 8 The replacement of the roof is planned for 2015 at a capital expenditure of \$900,000.

### 9 **Justification**:

- 10 Garland Canada concluded that the rooftops at each of the John Street building, Hughson
- 11 Street building, Hughson Substation building, and parking garage. had reached end-of-life and
- were in poor condition.
- 13 There were visible signs of deterioration. The rooftop membranes were starting to de-granulate,
- 14 reducing the strength and UV resistance of the rooftop. Some adjacent exterior walls were in
- 15 very poor condition and required new cladding, stucco or coating. There were some blisters on
- 16 the rooftops which are caused when air and/or air vapour is trapped. Previous repairs to the
- 17 rooftops have degraded and water leaks have damaged the windows and floor walls below.
- 18 The capital expenditure includes repair of surrounding walls, which are damaged, and the cost
- 19 of replacement and expansion of the roof railing to ensure compliance with the OBC. The
- 20 forecast is based on \$18 per square foot, which is consistent with industry comparators.
- 21 Horizon Utilities will conduct an RFP to obtain competitive pricing in accordance with Horizon
- 22 Utilities' procurement practices as defined within its Procurement Policy.
- 23 Additional Information: The following project John Street Roof Replacement exceeds Horizon
- 24 Utilities' materiality threshold and is individually identified and justified in the Material Project
- 25 Templates in Appendix G.

26

2015 John St Building Roof Replacement

- 2 Project Name: Nebo Road Business Continuity
- 3 **Driver:** General Plant
- 4 **Scope:** This project covers the installation of a 300kW permanent backup generator at Nebo
- 5 Road service center to allow the facility to function and operate independent of the electrical
- 6 distribution grid during power outages.
- 7 An investment of \$300,000 is required in 2015 to complete this project.
- 8 **Justification:** Nebo Road, Horizon Utilities' largest Service Center, supports all customers in
- 9 the Hamilton service area and is the Emergency Control Centre for the outside operations
- 10 during emergencies. Horizon Utilities has experienced outages to the Nebo Service Centre
- 11 during large scale outages, and the dispatching of emergency crews and contractors was
- 12 hampered. Portable generators did supply partial power to the building for lights and gas
- 13 pumps, but major electrical equipment such as overhead cranes and fleet hoists were not in
- service. The use of portable generators is no longer an option due to their non-conformance
- with safety regulations.
- 16 The Nebo Road electrical service was evaluated in 2013 by T. Lloyd Electric, a leading full
- 17 service electrical contractor, who concluded that in order to safely connect a generator to power
- 18 the Service Centre in the event of a power failure, Horizon Utilities would need to modify the
- 19 existing switchgear and install an automatic transfer switch for the generator.
- 20 The report issued by T. Lloyd Electric recommended the installation of a 300kW generator to
- 21 provide permanent back up power to the facility. The cost to install a new generator and
- associated equipment is forecasted at \$300,000 in 2015.
- 23 Additional Information: The following project Nebo Road Business Continuity exceeds
- 24 Horizon Utilities' materiality threshold and is individually identified and justified in the Material
- 25 Project Templates in Appendix G.
  - 2015 Nebo Road Business Continuity

- 1 2016 System Renewal Projects
- 2 Project ID: SR-8
- 3 Project Name: Gage TS Egress Feeder Renewal
- 4 **Driver:** System Renewal
- 5 **Scope:** The scope of this project involves the replacement of the egress cables at Gage TS to
- 6 facilitate Hydro One Networks' renewal of the station. This investment forecast has been
- developed based on the preliminary plans provided by Hydro One as of February 25, 2014.
- 8 An investment of \$4,793,000 in 2016 is required to complete this project.
- 9 Justification of Project: Gage TS is one of the oldest transformer stations within Hydro One's
- 10 inventory and the oldest station in Horizon Utilities' service territory. This station services
- 11 Horizon Utilities' two largest industrial customers, and has experienced a number of major
- 12 equipment failures that have affected these customers. Hydro One has scheduled the renewal
- of Gage TS starting in 2015. This is a multi-year project for Hydro One, but Horizon Utilities
- portion of work is scheduled for 2016. This project involves moving 56 cables from their existing
- 15 position to the new Hydro One bus structure that is being built approximately 210m away. A
- total of 11.7km of cable will be replaced.
- 17 A staged migration of cables from the old equipment to new equipment must occur in order to
- 18 minimize the downtime of sensitive industrial Horizon customers connected to Gage TS.
- 19 Additional civil duct work will be required due to constraints with the existing duct structure.
- 20 Additional Information: The following project within the Gage TS Egress Feeder Renewal
- 21 Program exceeds Horizon Utilities materiality threshold and is individually identified and justified
- in the Material Project Templates in Appendix G.
  - Gage TS Egress Feeder Renewal

- 1 2017 System Service Projects
- 2 Project ID: SS-5
- 3 Project Name: Duct Structure Elgin TS to King St.
- 4 **Driver:** System Service
- 5 **Scope:** This project involves the installation of additional civil capacity to support 4kV renewal
- 6 and address general load growth in the downtown Hamilton operating area.
- 7 An investment of \$535,000 in 2017 is required to complete this project.
- 8 Justification of Project: Horizon Utilities does not have adequate civil infrastructure to create
- 9 the feeder interties required to support the 4kV conversion and general load growth in the
- Hamilton Downtown area. The installation of these ducts runs along the border of Elgin TS and
- 11 Stirton TS. This civil infrastructure will support the interconnections required between these
- 12 stations to provide backup and reduce the impact of a major outage at either station.
- 13 Additional Information: The following project within the Duct Structure Program exceeds
- 14 Horizon Utilities' materiality threshold and is individually identified and justified in the Material
- 15 Project Templates in Appendix G.
- Duct Structure Elgin TS to King St

- 1 2018 System Service Projects
- 2 Project ID: SS-6
- 3 Project Name: East 16<sup>th</sup> and Mohawk Security Project
- 4 Driver: System Service
- 5 **Scope:** A school, Seniors Centre, and other commercial buildings are on a 13.8kV radial circuit
- 6 with no backup and are susceptible to long duration outages for repair in the event of a failure.
- 7 Additional underground civil structures and underground cable are required to complete a loop
- 8 feed to correct this deficiency and provide greater security.
- 9 An investment of \$324,000 is required in 2018 to complete this project.
- 10 Justification of Project: A variety of commercial customers are fed from a 13.8kV radial line
- 11 with no adjacent ties. The line directly feeding the school experienced a cable fault in 2011
- which caused the school to be closed for two days until repairs were made. This presents an
- 13 unacceptable risk to these critical customers.
- 14 Additional Information: This project exceeds the materiality threshold and is individually
- 15 identified and justified in the Material Project Templates in Appendix G.
- East 16<sup>th</sup> and Mohawk Security Project

- 1 Project ID: SS-7
- 2 Project Name: St. Paul Street Conductor Upgrade
- 3 Driver: System Service
- 4 **Scope:** This project will upgrade the feeder capacity along St. Paul Street in St. Catharines and
- 5 builds on the Vansickle TS upgrade completed in 2009.
- 6 An investment of \$1,362,000 is required in 2018 to complete this project.
- 7 Justification of Project: Horizon Utilities requested additional feeders and capacity from
- 8 Hydro One for Carlton TS in 2007. Horizon Utilities and Hydro One agreed that, due to difficulty
- 9 and cost, the alternative of providing these feeders and capacity at Vansickle TS was the better
- 10 option. This upgrade was required to provide capacity to service load growth in the west end of
- 11 St. Catharines and to provide additional backup and load transfer capabilities through increased
- 12 interconnections with adjacent TSs. Hydro One also requested that due to the overloading at
- 13 Carlton TS that load be transferred from Carlton TS to Vansickle TS. The upgrade was
- 14 completed in 2010. Since then, Horizon Utilities has been completing projects to take advantage
- of the capacity and security of the upgraded Vansickle TS.
- 16 This project is required to alleviate a capacity constraint on the Vansickle M53 feeder ("VSM53")
- 17 along St. Paul street by upgrading the conductor to full capacity. The VSM53 cannot properly
- support a load transfer from Carlton TS, without this upgrade.
- 19 The higher ampacity gained from upgrading this section of conductor would allow the VSM53 to
- 20 back up the adjacent feeder. This would also improve overall system security as the VSM53
- 21 would be able to handle more load in a back-up scenario.
- 22 Additional Information: The following project within the Paul Street Conductor Program
- 23 exceeds Horizon Utilities' materiality threshold and is individually identified and justified in the
- 24 Material Project Templates in Appendix G.
- St. Paul St Conductor Upgrade

26

- 1 2019 System Service Projects
- 2 Project ID: SS-8
- 3 Project Name: Grays Road
- 4 **Driver:** System Service
- 5 **Scope:** Building a loop supply to customers currently on a radial feeder; these customers are a
- 6 mix of commercial and residential and are on Grays Road north of the QEW.
- 7 This project requires an investment of \$413,000 in 2019.
- 8 Justification of Project: Past security reviews have flagged this radial section as high risk for
- 9 prolonged outages. The solution to this problem involves installing an intertie to a neighbouring
- 10 feeder to create a loop feed to provide customers with proper backup supply in the event of an
- 11 equipment failure. In 2013, the radial cable supplying this area had a failure and customers
- 12 were without power for over 24 hours until repairs were made. The project has not been
- previously completed as the project could not be included within the approved budget envelopes
- 14 and was displaced by higher priority projects.
- 15 Additional Information: The following project within the Grays Road Program exceeds Horizon
- 16 Utilities materiality threshold and is individually identified and justified in the Material Project
- 17 Templates in Appendix G.
- Security Lake 141X Grays Rd

19

# 1 Project ID: SS-9

2 Project Name: Mohawk/Nebo TS Upgrade

3 **Driver:** System Service

- 4 **Scope:** Capacity increases at Mohawk TS or Nebo TS (13.8kV) to support customer growth in
- 5 the central mountain area of Hamilton. The first payment in 2019 is estimated at \$1,000,000
- 6 based on other TS upgrade projects.
- 7 Justification of Project: Long term load forecasts have projected capacity issues on the
- 8 13.8kV system fed from Mohawk TS and Nebo TS (13.8kV). Even with projecting a modest
- 9 growth percentage, the busses at these TSs are encroaching on the 10-day LTR<sup>2</sup> limit. Horizon
- 10 Utilities has discussed this project on several occasions with Hydro One regarding the need for
- 11 review and assessment. Mohawk TS has passed the 10-day LTR for three out of the last four
- 12 years. A capacity increase at either station will be required to alleviate the loading at the bus
- 13 level. This project will be financed similarly to historical TS capacity upgrade projects (Vansickle
- 14 TS and Nebo TS) in that its payment will be spread over multiple years.
- 15 Additional Information: The following project Mohawk/Nebo T/S Upgrade Program exceeds
- 16 Horizon Utilities materiality threshold and is individually identified and justified in the Material
- 17 Project Templates in Appendix G.

18

Mohawk/Nebo TS Upgrade

\_\_\_\_

<sup>&</sup>lt;sup>2</sup> The capacity of a Hydro One transformer at TS is determined by its ability to safely withstand a certain loading level for 10 continuous days without a perceptible impact in the expected life of the transformer. This is termed the "10 day long term rating" (10 day LTR). Loading a TS transformer above this 10 day LTR design limit will shorten its useful life expectancy. The 10 day LTR ratings are monitored closely and not exceeding this limit for any appreciable time limit is strictly desirable.

#### 1 2019 General Plant Projects

- 2 Project ID: GP-7
- 3 **Project Name**: Building Renovations Stoney Creek
- 4 **Driver:** General Plant
- 5 **Scope:** One project is planned for 2019, primarily to address employee and public safety
- 6 concerns at the Stoney Creek Service Centre and replace end-of-life systems. The Stoney
- 7 Creek Service Centre is a centralized training location for Horizon Utilities and a satellite office
- 8 for Utility Operations.
- 9 The project will include the renovation of the locker, washroom, and shower space, and replace
- 10 end-of-life plumbing, lighting, HVAC, and fire and life support systems. These renovations will
- support the needs of the current and future workforces, and improve employee safety due to the
- 12 renewal of fire and life support systems.
- 13 This project requires an investment of \$1,200,000 in 2019.
- 14 Justification of Project:
- 15 The Stoney Creek Service Centre is utilized as an outdoor trades training facility and is a
- service centre for the east end of Horizon Utilities' service territory.
- 17 The project will include:

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- the renovation of the locker, washroom, and shower space to replace end-of life assets;
- the replacement of end-of-life plumbing, lighting, and HVAC;
- the replacement of fire and life support systems:

 The creation of a centralized storage location for records retention and storage of furniture and assets. This would address improper storage of equipment at Head Office and resolve compliance issues with fire codes and building codes for the Head Office and the Stoney Creek locations.

- 1 Additional Information: The following project Stoney Creek Service Centre Renovations -
- 2 exceeds Horizon Utilities materiality threshold and is individually identified and justified in the
- 3 Material Project Templates in Appendix G.

4

2019 Facility Renovations – Stoney Creek

# Appendix B - Kinectrics' 2013 Asset Condition Assessment





# HORIZON UTILITIES 2013 Asset Condition Assessment

November 27, 2013

Confidential & Proprietary Information
Contents of this report shall not be disclosed without authority of client.
Kinectrics Inc.
800 Kipling Avenue
Toronto, ON
M8Z 6C4 Canada
www.kinectrics.com

| Horizon Utilities               |
|---------------------------------|
| 2013 Asset Condition Assessment |
|                                 |

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# HORIZON UTILITIES 2013 ASSET CONDITION ASSESSMENT

Kinectrics Report: K-418442-RA-0001-R03

|  | •                 |
|--|-------------------|
|  | November 27, 2013 |
| Prepared by:   |                   |
| Att  | - SER PROFE       |
| Fan Wang, Ph.D. P. Eng.<br>Senior Engineer/Scientist     | S F.V             |
|  | 1000              |
| Reviewed by:   | POMOS             |
| 差别员  |                   |
| Juming Huang, Ph.D. P. Eng.<br>Senior Engineer/Scientist |                   |
| <b>0</b> ,   |                   |
| Approved by:  Amuni                                      |                   |
| Yury Tsimberg, M.Eng. P.Eng. Director – Asset Management |                   |
| 2013 -11-27 Dated:                                       |                   |

**To:** Horizon Utilities

55 John Street North

Hamilton, ON L8R 3M8

## **EXECUTIVE SUMMARY**

Horizon Utilities determined a need to perform a condition assessment of its key distribution assets. Such an undertaking would result in a quantifiable evaluation of asset condition, aid in prioritizing and allocating sustainment resources, as well as facilitate further development of their Asset Management Plan.

In 2013, Horizon Utilities selected and engaged Kinectrics Inc. (Kinectrics) to perform an Asset Condition Assessment (ACA) on Horizon Utilities key distribution assets.

The assets were divided into the following asset categories:

- Substation Transformers
- Substation Circuit Breakers
- Substation Switchgear
- Pole Mounted Transformers
- Overhead Conductors
- Overhead Line Switches
- Wood Poles
- Concrete Poles
- Underground Cables
- Pad Mounted Transformers
- Pad Mounted Switchgear
- Vault Transformers
- Utility Chambers
- Vaults
- Submersible Load Break Switches

For each asset category, the ACA included the following tasks:

- Gathering relevant condition data
- Developing a Health Index Formula
- Calculating the Health Index for each asset
- Determining the Health Index distribution
- Developing a 20-year condition-based Flagged-For-Action Plan
- Recommending condition data availability improvements

This Asset Condition Assessment Report summarizes the methodology and approaches used in this project, and present the resulting findings and recommendations.

#### Asset Condition Assessment Methodology

The Asset Condition Assessment Methodology involves the process of determining asset Health Index, as well as developing a Condition-Based Flagged-For-Action Plan for each asset category.

#### Health Index

Health Indexing quantifies equipment condition based on numerous condition parameters related to the long-term degradation factors that cumulatively lead to an asset's end of life. The Health Index is an indicator of the asset's overall health, relative to a brand new asset, and is given in terms of percentage, with 100% representing an asset in brand new condition.

The condition data used in this study were obtained from Horizon Utilities and included the following:

- Asset Properties (e.g. age, asset type, location information)
- Test Results (e.g. Oil Quality, DGA)
- Horizon Utilities database, e.g. GIS database
- Expert opinion of Horizon Utilities technical staff

A Health Index was calculated for each asset with sufficient condition data. As well, in order to provide an effective overview of the condition of each asset category, the Health Index Distribution for each asset category was determined.

#### Condition-Based Flagged-For-Action Plan

Once the Health Indices were calculated, a Flagged-For-Action Plan based on asset condition was developed. The Condition-Based Flagged-For-Action Plan outlines the number of units that are expected to be replaced or have action plan developed for addressing their deteriorating condition in the next 20 years. The numbers of units were estimated using either a *reactive* or *proactive* approach.

For assets with a relatively small consequence of failure, units are generally replaced <u>reactively</u> or following a failure. The Flagged-For-Action Plan for such an approach is based on the asset group's failure rate. This approach incorporates the possibility that assets may fail prematurely, prior to their expected typical end of lives, or, conversely, may last longer than the typical end of life.

In the <u>proactive</u> approach, units are assumed to be replaced or refurbished to extend their original end of life prior to failure. For asset groups that fall under this approach, a risk assessment was used to determine the units to be considered for replacement. This process first establishes a relationship between asset Health Index and the corresponding probability of failure. Also involved was the quantification of asset criticality through the assignment of weights and scores to factors that impact consequence of failure. The combination of criticality and probability of failure determines risk and Flagged–For-Action priority for that unit. It is worth noting that for proactively replaced units replacement is not the only option: the appropriate actions could include refurbishment, modifying spares strategy, e.g. keeping a spare units ready if failure were to occur, installing real time monitoring devices with alarms indicating an imminent failure based on specific real time measurements, or "doing nothing" in some cases with low criticality and/or where replacement with larger units due to the system growth is planned in the near future.

#### **Health Index Results**

Figure 1 shows a graphical summary of the Health Index evaluation results. It is seen from the summary that based on their derived condition the assets with at least 20% of the units in "very poor" or "poor" condition are:

- substation circuit breakers
- substation switchgear
- overhead line switches
- underground XLPE primary, secondary and direct buried service cables
- vault transformers
- submersible LBD switches

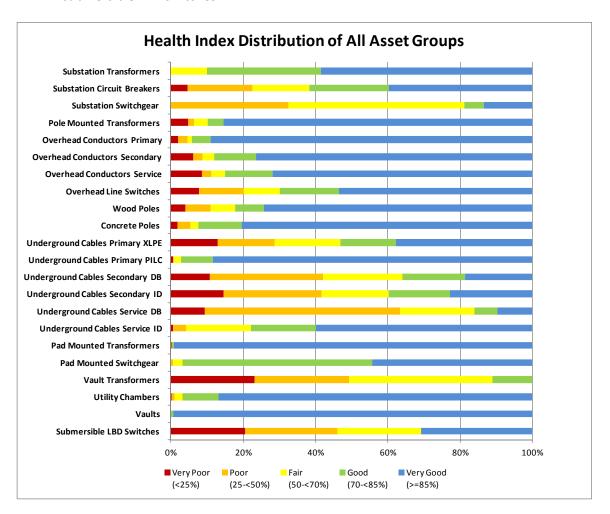


Figure 1 Visual Summary of Health Index Results

These assets represent a mix of proactively and reactively replaced assets and, therefore, the strategy of dealing with their overall condition degradation should be developed based on the most cost effective course of action for each asset category.

## **Condition Based Flagged-For-Action Plan**

Table 1 shows the condition-based Flagged-For-Action Plan for the first year and the type of asset replacement strategy typically used for each asset group.

Horizon Utilities most significant replacements relative to the population size (5 % or more) in the year one are expected to be for substation circuit breakers, pole mounted transformers, overhead service conductors, primary underground XLPE cables, vault transformers, and submersible LBD switches.

Table 1 Year 1 Condition-Based Flagged-For-Action Plan

| Asset                       | Sub-Category | Condition<br>Flagged-I<br>Plan fo | on-Based<br>For-Action<br>r Year 1 | Flagged-for-<br>Action<br>Percentage<br>for Year 1 | Primary<br>Replacement<br>Strategy |
|-----------------------------|--------------|-----------------------------------|------------------------------------|--|------------------------------------|
| Substation Transformers     | -            |                                   | 0                                  | 0%   | proactive                          |
| Substation Circuit Breakers | -            | 1                                 | .6                                 | 6%   | proactive                          |
| Substation Switchgear       | -            |                                   | 1                                  | 3%   | proactive                          |
| Pole Mounted Transformers   | -            | 5                                 | 93                                 | 5%   | reactive                           |
|                             | Primary      | 53                                | km                                 | 2%   | reactive                           |
| Overhead Conductors         | Secondary    | 86                                | km                                 | 4%   | reactive                           |
|                             | Service      | 97                                | km                                 | 5%   | reactive                           |
| Overhead Line Switches      | -            | (3)                               | 31                                 | 4%   | reactive                           |
| Wood Poles                  | -            | 15                                | 509                                | 4%   | reactive                           |
| Concrete Poles              | -            | g                                 | )7                                 | 1%   | reactive                           |
|                             | Primary      | XLPE                              | 126 km                             | 6%   | reactive                           |
|                             | Filliary     | PILC                              | 11 km                              | 1%   | reactive                           |
| Underground Cables          | Secondary    | DB                                | 28 km                              | 4%   | reactive                           |
| Officer ground Cables       | Secondary    | ID                                | 21 km                              | 4%   | reactive                           |
|                             | Service      | DB                                | 20 km                              | 4%   | reactive                           |
|                             | Service      | ID                                | 10 km                              | 2%   | reactive                           |
| Pad Mounted Transformers    | -            | 17                                |                                    | 0%   | reactive                           |
| Pad Mounted Switchgear      | -            | 3                                 |                                    | 2%   | reactive                           |
| Vault Transformers          | -            | 309                               |                                    | 7%   | reactive                           |
| Utility Chambers            | -            | 12                                |                                    | 1%   | reactive                           |
| Vaults                      |              | 6                                 |                                    | 0%   | reactive                           |
| Submersible LBD Switches    | -            | 1                                 | .4                                 | 12%  | reactive                           |

#### **Data Assessment**

In general, sufficient data and/or information were available for all the asset categories to develop a meaningful Health Index distribution.

Sufficient information and data were available for ACA study for all the three asset categories inside substations (namely <u>substation transformers</u>, <u>substation circuit breakers and substation switchgear</u>), as well as wood poles and pad mounted switchgear to develop a credible Health Index distribution.

Distribution transformers (<u>pole mounted</u>, <u>pad mounted</u> and <u>vault transformers</u>) in addition to their age had a count of occasions in 2011 and 2012 when their loading exceeded the nameplate rating: this information, which is rarely available in other utilities, was included in the calculation and resulted in identifying for replacement some specific units.

<u>Wood pole</u> testing data for 2011 and 2012 were incorporated in deriving their Health Index distribution.

For <u>pad mounted switchgear and utility chambers</u> age and available inspection records were used to determine Health Index distribution.

For the remaining asset categories age was the primary driver for determining Health Index distribution.

The main areas were efforts should be made to improve or maintain condition data availability is:

- Establish DGA trending by individual gases for substation transformers
- Start Partial Discharge (PD) testing for XLPE underground cable (scheduled to begin in 2014)

#### **Conclusions and Recommendations**

An Asset Condition Assessment was conducted for fifteen of Horizon Utilities distribution asset categories. For each asset category, the Health Index distribution was determined and a condition-based 20-year Flagged-For-Action Plan was developed.

- 1. In general, sufficient data and/or information were available for all the asset categories to develop a meaningful Health Index distribution. Horizon Utilities should continue to existing data collection practices with some improvements as recommended in the Data Assessment section above.
- 2. Horizon Utilities investment in substation infrastructure in recent years has been effective in improving the overall health of the substation asset groups as compared to the previous asset condition assessments. Substation transformers are in good shape with substation circuit breakers and switchgear being in adequate condition. A small portion of breakers remain in poor condition.
- 3. For overhead asset groups (including conductors, pole top transformers, switches and poles), even though their overall condition is fairly good, because they represent large populations, a significant number of units were still determined to be in "very poor" and "poor" condition and sustained investments will be required over the next 20 years to maintain overall condition at the existing level.
- 4. For asset groups associated with underground system, XLPE cables, direct buried cables, secondary in-duct cables and submersible LBD switches have a significant portion of population in "very poor" and "poor" condition and substantial investments will be required over the next 20 years to improve the overall condition of these asset categories. Even though the overall condition of PILC cables, service in-duct cables and pad mounted transformers is fairly good, a sustained investment over the next 20 years is required to maintain their overall condition at the existing level.
- 5. The combination of health and installed population will require significant investment over the next 20 years in order to at least sustain the existing level of reliability in the following asset categories:
  - pole mounted transformers
  - overhead primary, secondary and service conductors
  - wood poles
  - underground primary XLPE cables
  - underground PILC cables
  - underground secondary/service direct buried cables
  - vault transformers
- 6. It is recommended to put in place asset specific program to not only address improving the overall condition of asset categories listed in point 4 above but also to maintain

existing overall condition level for the remaining asset categories, particularly the ones listed in point 5 above. Not doing so will results in deteriorating reliability performance, taking unnecessary risks associated with failures of assets with significant consequence of failure (such as underground cables, substation breakers and overhead conductors) and bow wave of future investment needs that would be substantially higher than the historical levels.

7. It is important to note that the recommendations in this report are primarily condition-based. In putting in place a long-term asset strategy other factors, such as obsolescence, system growth, municipal initiatives, Regional Integrated Planning, etc. should be taken into account. Furthermore, the appropriate cost effective action for units flagged for action should be selected by considering options other than replacement, such as refurbishment, spare units strategy adjustment, intensified maintenance, real time monitoring or "doing nothing". This is particularly effective when dealing with proactively replaced assets.

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I INTRODUCTION

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#### I Introduction

Horizon Utilities is a local distribution company that distributes electricity to over 240,000 customers in the City of Hamilton and St. Catharines.

Horizon Utilities is wholly-owned by Horizon Holdings Inc. ("HHI"). HHI is a holding company that is a subsidiary of Hamilton Utilities Corporation ("HUC"), which owns 78.9% of the common shares of HHI. HUC is wholly owned by the City of Hamilton. The remaining 21.1% of the common shares of HHI are owned by St. Catharines Hydro Inc. ("SCHI"). SCHI is wholly owned by the City of St. Catharines. Horizon Utilities activities, performance standards, and rates are regulated by the Ontario Energy Board.

Kinectrics Inc. (Kinectrics) is an independent consulting engineering company with the advantage of over 100 years of expertise gained as part of one of North America's largest integrated electric power companies. Kinectrics has a depth of experience in the area of transmission and distribution systems and has become a prime source of Asset Management and Asset Condition services to some of the largest power utilities in North America.

In 2013, Horizon Utilities selected and engaged Kinectrics Inc. (Kinectrics) to perform an Asset Condition Assessment (ACA) on Horizon Utilities key distribution assets.

The Asset Condition Assessment Report summarizes the methodology, demonstrates specific approaches used in this project, and presents the resultant findings and recommendations.

#### 1.1 Objective and Scope of Work

The assets in this study are categorized as follows:

- Substation Transformers
- Substation Circuit Breakers
- Substation Switchgear
- Pole Mounted Transformers
- Overhead Conductors
  - o Primary
  - Secondary
  - o Service
- Overhead Line Switches
- Wood Poles
- Concrete Poles
- Underground Primary Cables
  - o Primary (XLPE, PILC)
  - Secondary (Direct Buried, In-Duct)
  - Service (Direct Buried, In-Duct)

- Pad Mounted Transformers
- Pad Mounted Switchgear
- Vault Transformers
- Utility Chambers
- Vaults
- Submersible LBD Switches

For each asset category, the ACA included the following tasks:

- Gathering relevant condition data
- Developing a Health Index Formula
- Calculating the Health Index for each asset
- Determining the Health Index distribution
- Developing a 20-year condition-based flagged-for-action plan
- Data assessment

#### 1.2 Deliverables

The deliverables in this study include spread sheets containing all the calculations performed by Kinectrics and this Report that includes the following information:

- Description of methodology for condition assessment of Flagged-For-Action Plan (Section II)
- Data Assessment (Section III)
- Overall Results (Section IV)
- Conclusions and Recommendations (Section V)
- For each asset category the following are included (VI Appendix A: Results and Findings for Each Asset Category, sub-Sections 1-15):
  - Short description of the asset groups and a discussion of asset degradation and end-of-life issues
  - o Age distribution
  - o Health Index formulation
  - Health Index distribution
  - o Condition-based Flagged-For-Action Plan
  - Data Assessment

II ASSET CONDITION ASSESSMENT METHODOLOGY

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# II Asset Condition Assessment Methodology

The Asset Condition Assessment (ACA) Methodology involves the process of determining asset Health Index, as well as developing a Condition-Based Flagged-For-Action Plan for each asset group. The methods used are described in the subsequent sections.

#### II.1 Health Index

Health Indexing quantifies equipment condition based on numerous condition parameters that are related to the long-term degradation factors that cumulatively lead to an asset's end of life. The Health Index is an indicator of the asset's overall health and is typically given in terms of percentage, with 100% representing an asset in brand new condition. Health Indexing provides a measure of long-term degradation and thus differs from defect management, whose objective is finding defects and deficiencies that need correction or remediation in order to keep an asset operating prior to reaching its end of life.

Condition parameters are the asset characteristics or properties that are used to derive the Health Index. A condition parameter may be comprised of several sub-condition parameters. For example, a parameter called "Oil Quality" may be a composite of parameters such as "Moisture", "Acid", "Interfacial Tension", "Dielectric Strength" and "Colour".

In formulating a Health Index, condition parameters are ranked, through the assignment of weights, based on their contribution to asset degradation. The condition parameter score for a particular parameter is a numeric evaluation of an asset with respect to that parameter.

Health Index (HI), which is a function of scores and weightings, is therefore given by:

$$HI = rac{\displaystyle\sum_{m=1}^{orall m} lpha_m (CPS_m imes WCP_m)}{\displaystyle\sum_{m=1}^{orall m} lpha_m (CPS_{m.\max} imes WCP_m)} imes DR$$
 Equation 1

where

$$CPS = \frac{\sum_{n=1}^{\forall n} \beta_n (CPF_n \times WCPF_n)}{\sum_{n=1}^{\forall n} \beta_n (WCPF_n)}$$
 Equation 2

 $\begin{array}{lll} \text{CPS} & \text{Condition Parameter Score (0 to 4)} \\ \text{WCP} & \text{Weight of Condition Parameter} \\ \alpha_{\text{m,}} \beta_{\text{n}} & \text{Data availability coefficient for condition parameter} \\ & & & & & & & & & & & & & & & & \\ & & & & & & & & & & & & & \\ & & & & & & & & & & & & \\ \text{CPF} & & & & & & & & & & & & \\ \text{Sub-Condition Parameter Score (0 to 4)} \\ \text{WCPF} & & & & & & & & & & & \\ \text{Weight of Sub-Condition Parameter} \\ \text{DR} & & & & & & & & & \\ \text{De-Rating Multiplier} \\ \end{array}$ 

The scale that is used to determine an asset's score for a particular parameter is called the *condition criteria*. For this project, a condition criteria scoring system of 0 through 4 is used. A score of 0 represents the worst score while 4 represents the best score. i.e.  $CPS_{max} = 4$ .

# II.1.1 Health Index Example

Consider the asset class "Oil Circuit Breaker". The condition and sub-condition parameters, as well as their weights are shown on Table II-1.

Table II-1 Oil Circuit Breaker Condition and Sub-Condition Parameters

| rable II-1 Oli Circi  | ait breaker Conditio | on and Sub-Condition Parar | ileteis        |
|-----------------------|----------------------|----------------------------|----------------|
| Health                | Index Formula fo     | or Oil Circuit Breakers    |                |
| Condition Param       | eters                | Sub-Condition P            | arameters      |
| Name                  | Weights (WCP)        | Name                       | Weights (WCPF) |
|                       |                      | Lubrication                | 9              |
| Operating Mechanism   | 14                   | Linkage                    | 5              |
|                       |                      | Cabinet                    | 2              |
|                       |                      | Closing Time               | 1              |
| Courts at Doufe was a | 7                    | Trip Time                  | 3              |
| Contact Performance   | 7                    | Contact Resistance         | 1              |
|                       |                      | Arcing Contact             | 1              |
|                       |                      | Moisture                   | 8              |
|                       |                      | Leakage                    | 1              |
| Arc Extinction        | 9                    | Tank                       | 2              |
|                       |                      | Oil Level                  | 1              |
|                       |                      | Oil Quality                | 8              |
| Insulation            | 2                    | Insulation                 | 1              |
|                       |                      | Operating Counter          | 2              |
| Service Record        | 5                    | Loading                    | 2              |
|                       |                      | Age                        | 1              |

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. The maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is therefore "4".

Scores are determined using *condition criteria*. Each criterion defines the score of a particular parameter. Consider, for example, the age criteria given on Table II-2. An asset that is 35 years old will receive a score of "2" for "Age".

Table II-2 Age Criteria

| Parameter Score | Condition Description |
|-----------------|-----------------------|
| 4               | 0-19                  |
| 3               | 20-29                 |
| 2               | 30-39                 |
| 1               | 40-44                 |
| 0               | 45+                   |

Table II-3 shows a sample Health Index evaluation for a particular oil breaker. The subcondition parameter scores (CPFs) shown are assumed values between 0 through 4.

The Condition Parameter Score (CPS) is evaluated as per Equation 2. The Health Index (HI) is calculated as per Equation 1. As no de-rating factors are defined, there is no multiplier for the final Health Index.

**Table II-3 Sample Health Index Calculation** 

| Condition Parameters               | Operating Mechanism            |  |                  | Contact Performance         |            |                  | Arc Extinction  |      |                  | Insulation                      |         |                  | Service Record                 |         |                  |
|------------------------------------|--------------------------------|--|------------------|-----------------------------|------------|------------------|---|------|------------------|---------------------------------|---------|------------------|--------------------------------|---------|------------------|
| Sub-Condition                      | Sub-<br>Condition<br>Parameter | CPF  | Weight<br>(WCPF) | Sub-Condition<br>Parameter  | CPF        | Weight<br>(WCPF) | Sub-Condition<br>Parameter                                    | CPF  | Weight<br>(WCPF) | Sub-<br>Condition<br>Parameter  | CPF     | Weight<br>(WCPF) | Sub-<br>Condition<br>Parameter | CPF     | Weight<br>(WCPF) |
| Parameters                         | Lubrication                    | 4  | 9                | Closing Time                | 2          | 1                | Moisture  | 4    | 8                | Insulation                      | 4       | 1                | Operating<br>Counter           | 3       | 2                |
| Scores (CPF)                       | Linkage                        | 2  | 5                | Trip Time                   | 3          | 3                | Leakage   | 3    | 1                |                                 |         |                  | Loading                        | 4       | 2                |
| Weights (WCPF)                     | Cabinet                        | 3  | 2                | Contact<br>Resistance       | 2          | 1                | Tank  | 3    | 2                |                                 |         |                  | Age                            | 3       | 1                |
|                                    |                                |  |                  | Arcing Contact              | 3          | 1                | Oil Level   | 2    | 1                |                                 |         |                  |                                |         |                  |
|                                    |                                |  |                  |                             |            |                  | Oil Quality   | 3    | 8                |                                 |         |                  |                                |         |                  |
|                                    | Operating M                    | echani   | ism CPS          | Contact Perfor              | rmanc      | e CPS            | Arc Extinction CPS (4*8+3*1+3*2+2*1+3*8) / (8+1+2+1+8) = 3.35 |      |                  | Insulation CPS<br>(4*1) / (1) = |         |                  | Service Record CPS             |         |                  |
| Condition Parameter<br>Score (CPS) | (4*9+2*5+3                     | *2) / (<br>25  | 9+5+2) =         | (2*1+3*3+2*1+3<br>=<br>2.61 |            | (1+3+1+1)        |   |      |                  |                                 |         |                  | (3*2 + 4*2 + 3*1) / (2+2+1) =  |         |                  |
| -                                  | 3.                             | 23   |                  | 2.0                         |            |                  | 3.3.  | ,    |                  |                                 | 4       |                  |                                | 3.4     |                  |
| Weights (WCP)                      | Weigl                          | ht = 14  | ı                | Weight                      | Weight = 7 |                  |   | t =9 |                  | Weig                            | ght = 2 | ?                | Wei                            | ght = 5 |                  |
| Health Index (HI)                  |                                | HI = (3.25*14 + 2.67*7 + 3.35*9 + 4*2 + 3.4*5) = <b>80.6</b> %<br>(14 + 7 + 9 + 2 + 5)*4 |                  |                             |            |                  |   |      |                  |                                 |         |                  |                                |         |                  |

#### II.1.2 Health Index Results

As stated previously, an asset's Health Index is given as a percentage, with 100% representing "as new" condition. The Health Index is calculated only if there is sufficient condition data. The subset of the population with sufficient data is called the *sample size*. Results are generally presented in terms of number of units and as a percentage of the sample size. If the sample size is sufficiently large and the units within the sample size are sufficiently random, the results may be extrapolated for the entire population.

The Health Index distribution given for each asset group illustrates the overall condition of the asset group. Further, the results are aggregated into five categories and the categorized distribution for each asset group is given. The Health Index categories are as follows:

 $\begin{array}{lll} \mbox{Very Poor} & \mbox{Health Index} < 25\% \\ \mbox{Poor} & 25 \leq \mbox{Health Index} < 50\% \\ \mbox{Fair} & 50 \leq \mbox{Health Index} < 70\% \\ \mbox{Good} & 70 \leq \mbox{Health Index} < 85\% \\ \mbox{Very Good} & \mbox{Health Index} \geq 85\% \\ \end{array}$ 

Note that for critical asset groups, such as Station Transformers, the Health Index of each individual unit is given.

# II.2 Condition-Based Replacement Methodology

The Condition-Based Flagged-For-Action Plan outlines the number of units that are projected to be replaced in the next 20 years. The numbers of units are estimated using either a *proactive* or *reactive* approach. In the proactive approach, units are considered for replacement prior to failure, whereas the reactive approach is based on expected failures per year.

Both approaches consider asset failure rate and probability of failure. The failure rate is estimated using the method described in the subsequent section.

#### II.2.1 Failure Rate and Probability of Failure

Where failure rate data is not available, a frequency of failure that grows exponentially with age provides the best model. This is based on the Gompertz-Makeham law of mortality. The original form of the failure function is:

$$f = \gamma e^{\beta t}$$

**Equation 3** 

f = failure rate per unit time

t = time

 $\gamma$ ,  $\beta$  = constant that control the shape of the curve

Depending on its application, there have been various forms derived from the original equation. Based on Kinectrics' expertise in failure rate study of multiple power system asset groups, the following variation of the failure rate formula is adopted:

$$f(t) = e^{\beta(t-\alpha)}$$

**Equation 4** 

f = failure rate of an asset (percent of failure per unit time)

t = age (years)

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding cumulative probability of failure function (thereafter referred to as probability of failure) is therefore:

$$P_f(t) = 1 - e^{-(f - e^{-\alpha\beta})/\beta}$$

**Equation 5** 

 $P_f$  = probability of failure

Different asset groups experience different failure rates and therefore different probabilities of failure. As such, the shapes of the failure and probability curves are different. The parameters  $\alpha$  and  $\beta$  are used to control the location and steepness of the exponential rise of these curves. For each asset group, the values of these constant parameters were selected to reflect typical useful lives for these assets.

Consider, for example, an asset class where at the ages of 25 and 65 the asset has probabilities of failure of 10% and 99% respectively. It follows that when using Equation 5,  $\alpha$  and  $\beta$  are calculated as 74 and 0.093 respectively. As such, for this asset class the probability of failure equation is:

$$P_f(t) = 1 - e^{-(e^{\beta(t-\alpha)} - e^{\alpha\beta})/\beta} = 1 - e^{-(e^{0.093(t-74)} - e^{-6.882})/0.093}$$

The failure rate and probability of failure graphs are as shown:

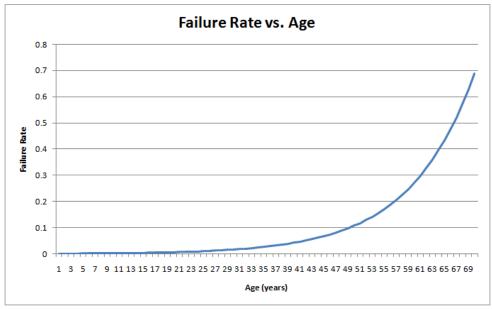


Figure II-1 Failure Rate vs. Age

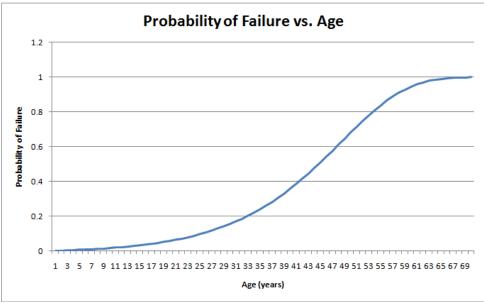


Figure II-2 Probability of Failure vs. Age

# II.2.2 Projected Flagged-For-Action Plan Using a Reactive Approach

Because their consequences of failure are relatively small, many types of distribution assets are reactively replaced.

For such asset types, the number of units expected to be replaced in a given year are determined based on the asset's failure rates. The number of failures per year is given by Equation 4:

$$f(t) = e^{\beta(t-\alpha)}$$

with  $\alpha$  and  $\beta$  determined from the probability of failure of each asset class.

An example of such a Flagged-For-Action Plan is as follows: Consider an asset distribution of 100 - 5 year old units, 20 - 10 year old units, and 50 - 20 year old units. Assume that the failure rates for 5, 10, and 20 year old units for this asset class are  $f_5 = 0.02$ ,  $f_{10} = 0.05$ ,  $f_{20} = 0.1$  failures / year respectively. In the current year, the total number of replacements is 100(.02) + 20(0.05) + 50(0.1) = 2 + 1 + 5 = 8.

In the following year, the expected asset distribution is, as a result, as follows: 8-1 year old units, 98-6 year old units, 19-11 year old units, and 45-21 year old units. The number of replacements in year 2 is therefore  $8(f_1) + 19(f_6) + 45(f_{11}) + 45(f_{21})$ .

Note that in this study the "age" used is in fact "effective age, or condition-based age where available, as opposed to the chronological age of the asset.

#### II.2.3 Projected Flagged-For-Action Plan Using a Proactive Approach

For certain asset classes, the consequence of asset failure is significant, and, as such, these assets are proactively replaced prior to failure. The proactive replacement methodology involves relating an asset's Health Index to its probability of failure by considering the stresses to which it is exposed.

#### Relating Health Index and Probability of Failure

Failure of an asset occurs when the stress to which an asset is exposed exceeds its strength. Assuming that stress is not constant, and that stress is normally distributed, the probability of stress exceeding asset strength leads to the probability of failure. This is illustrated in the figure below. A vertical line represents condition or strength (Health Index) and the area under the curve to the right of the Health Index line represents the probability of failure.

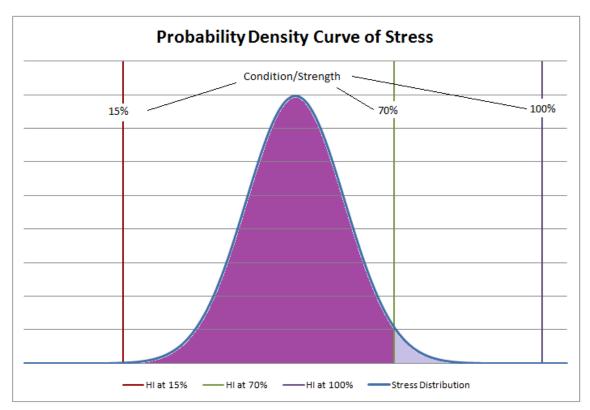


Figure II-3 Stress Curve

Two points of Health Index and probability of failure are needed to generate the probability of failure at other Health Index values. A Health Index of 100% represents an asset that is in brand new condition and a Health Index of 15% represents the asset's end of life. The 100% and 15% conditions are plotted on the stress curve by finding the points at which the areas under the stress curve are equal to  $P_{f\,100\%}$  (age at 100% Health Index) and  $P_{f\,15\%} = P_f$  (age at 15% Health Index). By moving the vertical line left from 100% to 15%, the probabilities of failure for other Health Indices can be found.

The probability of failure at a particular Health Index is found from plotting the Health Index on the X-axis and the area under the probability density curve to the right of the Health Index line on the Y-axis as shown on the graph of the figure below.

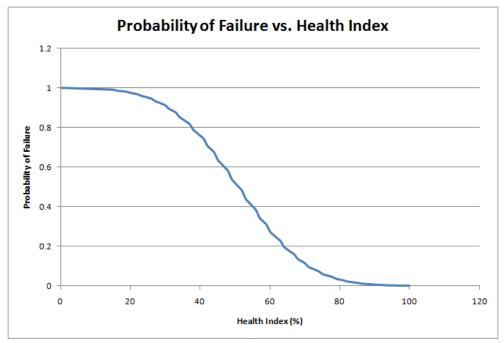


Figure II-4 Probability of Failure vs. Health Index

#### Relating Health Index to Effective Age

Once the relationship between probability of failure and Health Index has been found, the "effective age" of an asset can be determined. The "effective age" is different from chronological age in that it is based on the asset's condition and the stresses that are applied to the asset.

The probability of failure associated with a specific Health Index can be found using the Probability of Failure vs. Health Index (Figure II-4) and Probability of Failure vs. Age (Figure II-2). The probability of failure at a particular Health Index can be found from Figure II-4. The same probability of failure is located on Figure II-2, and the effective age is on the horizontal axis of Figure II-2. See example on the Figure II-5 below where a Health Index of 60% corresponds to an effective age of 35 years.

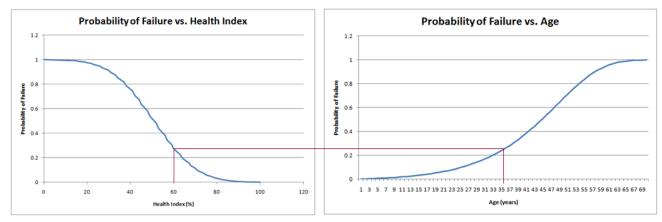


Figure II-5 Effective Age

#### Condition-Based Flagged-For-Action Plan

In order to develop a Flagged-For-Action Plan, the risk of failure of each unit must be quantified. Risk is the product of a unit's probability of failure and its consequence of failure.

The probability of failure is determined by an asset's Health Index. In this study, the metric used to measure consequence of failure is referred to as *criticality*.

Criticality may be determined in numerous ways, with monetary consequence or degree of risk to corporate business values being examples. For Substation Transformers, factors that impact criticality may include things like number of customers or location. The higher the criticality value assigned to a unit, the higher is it's consequence of failure.

It is assumed in this study that each asset group has a base criticality value,  $Criticality_{min}$ . The individual units in the asset group are assigned Criticalities that are multiples of  $Criticality_{min}$ . A unit becomes a candidate for replacement when its risk value, the product of its probability of failure and Criticality, is greater than or equal to 1.

In the example shown below, Asset 1 and Asset 2 are candidates for replacement.

**Table II-4 Sample Replacement Ranking** 

| Asset<br>Name | Age | Health<br>Index<br>(HI) | Consequence<br>of Failure<br>(Criticality) | Probability of<br>Failure (POF)<br>Corresponding to<br>HI | Risk<br>(POF*Criticality) | Replacement<br>Ranking |
|---------------|-----|-------------------------|--|---|---------------------------|------------------------|
| Asset 1       | 41  | 30.00%                  | 2 82.5%                                    |   | 1.630                     | 1                      |
| Asset 2       | 29  | 30.00%                  | 1.5  | 82.5%   | 1.237                     | 2                      |
| Asset 3       | 37  | 30.00%                  | 0.00% 1 78.20% 0.78                        |   | 0.782                     | 3                      |
| Asset 4       | 42  | 50.00%                  | 2  | 12.80%  | 0.256                     | 4                      |
| Asset 5       | 18  | 50.00%                  | 1.5  | 12.80%  | 0.192                     | 5                      |
| Asset 6       | 20  | 50.00%                  | 1  | 12.80%  | 0.128                     | 6                      |

# II.3 Flagged-For-Action Plan

For *proactively* replaced assets, the Condition-Based Flagged-For-Action Plan considers assets for replacement once their probability of failure becomes equal to or exceeds 80%. Assets are then Flagged-For-Action in a year when their Risk Score which is calculated as a product of probability of failure times criticality exceeds 1.1875 (1.1875 value represents Risk Score for an asset with a Criticality<sub>min</sub> of 1.25 and probability of failure equal to 95% assumed to be the maximum acceptable probability of failure). Assets are automatically Flagged-For-Action when their probability of failure is equal to or exceeds 95%, regardless of their criticality.

For *reactively* replaced assets, the Condition-Based Flagged-For-Action Plan is determined by the probability of failure curves.

# III DATA ASSESSMENT

# **III Data Assessment**

The condition data used in this study were obtained from Horizon Utilities and included the following:

- Asset Properties (e.g. age, equipment ID, location information)
- Test Results (e.g. Oil Quality, DGA, wood pole testing)
- Distribution transformers overloading records
- Expert opinion of Horizon Utilities technical staff

For each asset category general description of what types of data/information were used is provided. When warranted, recommendation is also in included on what steps could be taken to improve ant existing data availability.

# IV RESULTS

# **IV** Results

This section summarizes the findings of this study.

#### **Health Index Results**

A summary of the Health Index evaluation results is shown in Table IV-1. The population and sample size, or number of assets with sufficient data for Health Indexing, are given (for underground cable asset categories population sizes for subsets of the population are shown in the "Sample Size" column, i.e. XLPE and PILC for primary cables, and direct buried and in-duct for secondary and service cables). For each asset category the Health Index Distribution, total number in "Poor" and "Very Poor" condition, and average age are shown.

It can be seen from the results that:

- 1. For substation asset groups, substation transformers are in good shape. Substation circuit breakers and switchgear are in adequate shape, except that a small portion of breakers need immediate action.
- 2. For overhead asset groups (including conductors, pole top transformers, switches and poles), even though their overall condition is fairly good, because they represent large populations, a significant number of units were still estimated to be in "very poor" and "poor" condition and sustained investments will be required over the next 20 years to maintain overall condition at the existing level.
- 3. For asset groups associated with underground system, primary XLPE cables, underground secondary cables and submersible LBD switches have a significant portion of population in "very poor" and "poor" condition and substantial investments will be required over the next 20 years to improve the overall condition of these asset categories. Even though the overall condition of PILC cables, pad mounted transformers and service in-duct cables is fairly good, a sustained investment over the next 20 years is required to maintain their overall condition at the existing level.

More specifically, the results show that based on their derived condition the assets with at least 20% of the units in "poor" or "very poor" condition are:

- substation switchgear
- overhead line switches
- underground XLPE primary, secondary and direct buried service cables
- vault transformers
- submersible LBD switches

# **Condition Based Flagged-For-Action Plan**

Table IV-2 shows the 20 year Flagged-For-Action Plan.

Once the Health Indices were calculated, a Flagged-For-Action Plan based on asset condition was developed. The Condition-Based Flagged-For-Action Plan outlines the number of units that are expected to be replaced in the next 20 years. The numbers of units were estimated using either a *reactive* or *proactive* approach. Table IV-2 also shows average annual replacement cost for each of the asset categories.

For assets with a relatively small consequence of failure, units are generally replaced <u>reactively</u> or on failure. The Flagged-For-Action Plan for such an approach is based on the asset group's failure rate. This approach incorporates the possibility that assets may fail prematurely, prior to their expected typical end of lives, or, conversely, may last longer than the typical end of life.

In the <u>proactive</u> approach, units are assumed to be replaced or refurbished to extend their original end of life prior to failure. For asset groups that fall under this approach, a Risk Assessment study was conducted to determine the units to be considered for replacement. This process first establishes a relationship between asset Health Index and the corresponding probability of failure. Also involved was the quantification of asset criticality through the assignment of weights and scores to factors that impact consequence of failure. The combination of criticality and probability of failure determines risk and Flagged–For-Action priority for that unit. It is worth noting that for proactively replaced units replacement is not the only option: the appropriate actions could include refurbishment, modifying spares strategy, e.g. keeping a spare units ready if failure were to occur, installing real time monitoring devices with alarms indicating an imminent failure based on specific real time measurements, or "doing nothing" in some cases with low criticality and/or where replacement with larger units due to the system growth is planned in the near future.

It is important to note that the Flagged-For-Action Plan suggested in this study is based solely on asset condition. It uses a probabilistic, non-deterministic, approach and as such can only show expected failures or probable number of units for replacement. While the Condition-Based Flagged-For-Action Plan can be used as a guide or input to Horizon Utilities' Replacement Plan, it is not expected to be followed directly or being used as the final deciding factor in making decisions regarding sustainment capital expenditures. There are numerous other factors and considerations that will influence Horizon Utilities' asset management decisions, such as obsolescence, municipal initiatives, distribution system growth, etc.

Horizon Utilities most significant expected replacements relative to the population size (5% or more) in the year one are expected to be for substation circuit breakers, pole mounted transformers, overhead service conductors, primary underground XLPE cables, vault transformers and submersible LBD switches.

**Table IV-1 Health Index Results Summary** 

|                               |      |              |            |           |             | ndex Distributio | n (Units)   |                 | Total of Poor            |
|-------------------------------|------|--------------|------------|-----------|-------------|------------------|-------------|-----------------|--------------------------|
| Asset                         |      | Sub-Category | Population | Very Poor | Poor        | Fair             | Good        | Very Good       | and Very Poor<br>(Units) |
|                               |      |              |            | (< 25%)   | (25 - <50%) | (50 - <70%)      | (70 - <85%) | ( <u>≥</u> 85%) | (55)                     |
| Substation Transformers       |      | -            | 70         | 0         | 0           | 7                | 22          | 41              | 0                        |
| Substation Circuit Breakers   |      | -            | 279        | 13        | 50          | 44               | 61          | 111             | 63                       |
| Substation Switchgear         |      | -            | 37         | 0         | 12          | 18               | 2           | 5               | 12                       |
| Pole Mounted Transformers     |      | -            | 12886      | 616       | 198         | 489              | 571         | 11012           | 814                      |
|                               |      | Primary      | 3386       | 65        | 90          | 40               | 173         | 3016            | 156                      |
| Overhead Conductors (in km)   |      | Secondary    | 2196       | 135       | 56          | 74               | 254         | 1677            | 191                      |
|                               |      | Service      | 1901       | 164       | 50          | 70               | 248         | 1365            | 214                      |
| Overhead Line Switches        | -    | 712          | 55         | 89        | 70          | 116              | 381         | 144             |                          |
| Wood Poles                    |      | -            | 42036      | 1723      | 2876        | 2836             | 3424        | 31176           | 4599                     |
| Concrete Poles                |      |              | 9761       | 171       | 354         | 214              | 1167        | 7855            | 525                      |
|                               | XLPE | Primary      | 3593       | 269       | 323         | 375              | 313         | 780             | 592                      |
| ables                         | PILC | Pilillaly    |            | 9         | 3           | 30               | 133         | 1356            | 13                       |
| Underground Cables<br>(in km) | DB   | Secondary    | 1290       | 82        | 236         | 166              | 132         | 140             | 318                      |
| (in                           | ID   | Secondary    | 1290       | 77        | 145         | 98               | 91          | 121             | 223                      |
| g apr                         | DB   | Service      | 1035       | 42        | 241         | 92               | 29          | 43              | 283                      |
| <u></u>                       | ID   | Jervice      | 1033       | 3         | 22          | 106              | 105         | 353             | 25                       |
| Pad Mounted Transformers      |      | -            | 5906       | 8         | 0           | 8                | 33          | 5857            | 8                        |
| Pad Mounted Switchgear        |      | -            | 186        | 0         | 1           | 5                | 97          | 82              | 1                        |
| Vault Transformers            | -    | 4169         | 966        | 1089      | 1657        | 457              | 0           | 2055            |                          |
| Utility Chambers              | -    | 2075         | 4          | 18        | 44          | 207              | 1802        | 22              |                          |
| Vaults                        |      | -            | 3413       | 0         | 0           | 2                | 16          | 3383            | 0                        |
| Submersible LBD Switches      |      | -            | 117        | 24        | 30          | 27               | 0           | 36              | 54                       |

**Table IV-2 Twenty Year Condition Based Flagged-For-Action Plan** 

|                             | Sub-     |                  | Avg. Annual                  |      |      |      |     |     |     |     |     |     | Flagged for | Action Year |     |     |     |     |     |     |     |     |     |
|-----------------------------|----------|------------------|------------------------------|------|------|------|-----|-----|-----|-----|-----|-----|-------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asset                       | Category | Total Population | Replacement Cost<br>(\$000s) | 1    | 2    | 3    | 4   | 5   | 6   | 7   | 8   | 9   | 10          | 11          | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  |
| Substation Transformers     | -        | 70               | \$ 37.50                     | 0    | 0    | 0    | 0   | 0   | 0   | 0   | 0   | 0   | 0           | 0           | 1   | 0   | 0   | 0   | 1   | 0   | 1   | 0   | 2   |
| Substation Circuit Breakers | -        | 279              | \$ 200.25                    | 16   | 0    | 10   | 0   | 11  | 0   | 9   | 0   | 17  | 0           | 7           | 0   | 0   | 0   | 0   | 9   | 1   | 0   | 0   | 9   |
| Substation Switchgear       | -        | 37               | \$ 975.00                    | 1    | 0    | 1    | 1   | 4   | 0   | 0   | 4   | 2   | 4           | 0           | 4   | 1   | 4   | 0   | 0   | 0   | 0   | 0   | 0   |
| Pole Mounted Transformers   | -        | 12886            | \$ 1,939.21                  | 593  | 277  | 232  | 218 | 215 | 217 | 220 | 223 | 226 | 228         | 229         | 229 | 230 | 230 | 231 | 234 | 238 | 244 | 252 | 262 |
|                             | Primary  | 3386             | \$ 1,480.86                  | 53   | 45   | 40   | 37  | 34  | 32  | 31  | 30  | 29  | 30          | 30          | 31  | 32  | 32  | 32  | 33  | 33  | 33  | 33  | 34  |
| Overhead Conductors         | Secondar | 2196             | \$ 1,747.96                  | 86   | 63   | 52   | 44  | 40  | 38  | 38  | 38  | 39  | 39          | 39          | 39  | 39  | 39  | 38  | 37  | 36  | 34  | 33  | 32  |
|                             | Service  | 1897             | \$ 1,677.46                  | 97   | 69   | 54   | 44  | 39  | 36  | 35  | 36  | 36  | 36          | 36          | 36  | 36  | 35  | 34  | 33  | 32  | 30  | 28  | 27  |
| Overhead Line Switches      | -        | 711              | \$ 262.31                    | 31   | 26   | 23   | 22  | 20  | 20  | 19  | 18  | 19  | 18          | 18          | 18  | 17  | 17  | 17  | 17  | 16  | 17  | 17  | 17  |
| Wood Poles                  | -        | 42037            | \$ 3,628.76                  | 1509 | 1103 | 1011 | 967 | 935 | 905 | 876 | 845 | 814 | 782         | 752         | 724 | 699 | 678 | 662 | 648 | 637 | 627 | 619 | 611 |
| Concrete Poles              | -        | 9761             | \$ 550.25                    | 97   | 98   | 100  | 101 | 103 | 104 | 105 | 107 | 108 | 109         | 110         | 111 | 112 | 114 | 115 | 118 | 119 | 121 | 123 | 126 |
|                             | ė XLPE   | 2060             | \$ 8,637.10                  | 126  | 103  | 96   | 91  | 88  | 85  | 83  | 80  | 78  | 76          | 74          | 72  | 71  | 70  | 69  | 68  | 67  | 66  | 66  | 66  |
|                             | PILC     | 1532             | \$ 4,190.48                  | 11   | 11   | 12   | 12  | 12  | 13  | 14  | 14  | 15  | 16          | 17          | 18  | 19  | 20  | 20  | 21  | 22  | 23  | 24  | 25  |
| Underground Cables          | DB ن     | 757              | \$ 3,240.93                  | 28   | 28   | 28   | 27  | 27  | 27  | 27  | 27  | 26  | 26          | 26          | 26  | 25  | 25  | 25  | 25  | 24  | 24  | 24  | 24  |
| Onderground Cables          | S D      | 533              | \$ 454.19                    | 21   | 21   | 21   | 20  | 20  | 19  | 19  | 19  | 18  | 18          | 18          | 18  | 17  | 17  | 17  | 17  | 17  | 16  | 16  | 16  |
|                             | . DB     | 446              | \$ 2,192.03                  | 20   | 20   | 20   | 19  | 19  | 19  | 19  | 18  | 18  | 18          | 18          | 17  | 17  | 17  | 16  | 16  | 16  | 15  | 15  | 15  |
|                             | Ser      | 588              | \$ 319.59                    | 10   | 11   | 11   | 11  | 11  | 12  | 12  | 12  | 13  | 13          | 13          | 13  | 14  | 14  | 14  | 14  | 14  | 15  | 15  | 15  |
| Pad Mounted Transformers    | -        | 5893             | \$ 937.53                    | 17   | 17   | 20   | 23  | 27  | 31  | 36  | 41  | 47  | 53          | 59          | 65  | 70  | 75  | 79  | 83  | 87  | 92  | 98  | 105 |
| Pad Mounted Switchgear      | -        | 186              | \$ 192.50                    | 3    | 3    | 3    | 3   | 3   | 3   | 3   | 3   | 3   | 3           | 3           | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 5   |
| Vault Transformers          | -        | 4169             | \$ 1,448.22                  | 309  | 294  | 282  | 270 | 260 | 250 | 240 | 230 | 221 | 212         | 203         | 194 | 186 | 178 | 170 | 162 | 156 | 150 | 144 | 139 |
| Utility Chambers            | -        | 2075             | \$ 389.60                    | 12   | 13   | 13   | 14  | 15  | 15  | 16  | 17  | 17  | 18          | 19          | 20  | 20  | 21  | 22  | 23  | 23  | 24  | 25  | 26  |
| Vaults                      | -        | 3413             | \$ 97.91                     | 6    | 7    | 7    | 7   | 8   | 8   | 9   | 10  | 10  | 11          | 12          | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  |
| Submersible LBD Switches    | -        | 117              | \$ 33.60                     | 14   | 8    | 7    | 6   | 5   | 5   | 5   | 4   | 4   | 4           | 3           | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 3   |

#### **Data Assessment Results**

In general, sufficient data and/or information were available for all the asset categories to develop a meaningful Health Index distribution, in fact for distribution transformers (pole mounted, pad mounted and vault) overloading information typically not available at other utilities was provided by Horizon Utilities.

Sufficient information and data were available for ACA study for all the three asset groups inside substations (namely <u>substation transformers</u>, <u>substation circuit breakers and substation switchgear</u>), as well as wood poles and pad mounted switchgear to develop a credible Health Index distribution.

Distribution transformers (<u>pole mounted</u>, <u>pad mounted</u> and <u>vault transformers</u>) in addition to their age had a count of occasions in 2011 and 2012 when their loading exceeded the nameplate rating. This information is used together with age as the condition parameters in health index calculation.

<u>Wood pole</u> testing data for 2011 and 2012 were incorporated in deriving their Health Index distribution.

For <u>pad mounted switchgear and utility chambers</u>, age and available inspection records were used to determine Health Index distribution.

For the remaining asset categories age was the primary driver for determining Health Index distribution.

The main areas were efforts should be made to improve or maintain condition data availability is:

- Establish DGA trending by individual gases for substation transformers
- Start Partial Discharge (PD) testing for XLPE underground cable (schedule to begin in 2014)
- Continue with tracking occasions when distribution transformers loading exceeds their nameplate rating

V CONCLUSIONS AND RECOMMENDATIONS

#### V Conclusions and Recommendations

- 1. An Asset Condition Assessment was conducted for fifteen of Horizon Utilities distribution asset categories. For each asset category, the Health Index distribution was determined and a condition-based 20-year Flagged-For-Action Plan was developed.
- 2. In general, sufficient data and/or information were available for all the asset categories to develop a meaningful Health Index distribution. Horizon Utilities should continue with the existing data collection practices with some improvements as recommended in the Data Assessment section above.
- 3. For substation asset groups, substation transformers are in good shape. Substation circuit breakers and switchgear are in adequate shape, except that a small portion of breakers need immediate action.
- 4. For overhead asset groups (including conductors, pole top transformers, switches and poles), even though their overall condition is fairly good, because they represent large populations, a significant number of units were still determined to be in "very poor" and "poor" condition and sustained investments will be required over the next 20 years to maintain their overall condition at the existing level.
- 5. For asset groups associated with underground system, XLPE cables, direct buried cables, secondary in-duct cables and submersible LBD switches have a significant portion of population in "very poor" and "poor" condition and substantial investments will be required over the next 20 years to improve the overall condition of these asset categories. Even though the overall condition of PILC cables, pad mounted transformers and service in-duct cables is fairly good, a sustained investment over the next 20 years is required to maintain their overall condition at the existing level.
- 6. There are a number of legacy units that need to be dealt with in order to at least sustain the existing level of reliability, particularly in the following asset categories:
  - distribution transformers, pole mounted and vault
  - primary, secondary and service overhead conductors
  - overhead line switches
  - wood poles
  - primary XLPE underground cables
  - vault transformers
  - submersible load break switches
- 7. It is recommended to put in place asset specific program to not only address improving the overall condition of these asset categories but also to maintain existing overall condition level for the remaining asset categories. Not doing so will results in deteriorating reliability performance, taking unnecessary risks associated with failures of assets with significant consequence off failure (such as underground cables, substation

breakers and overhead conductors) and bow wave of future investment needs that would be substantially higher than the historical levels and if a long-term investment strategy put in place at this time.

- 8. It is important to note that the recommendations in this report are primarily condition-based. In putting in place a long-term asset strategy other factors, such as obsolescence, system growth, municipal initiatives, Regional Integrated Planning, etc. should be taken into account. Furthermore, the appropriate cost effective action for units flagged for action should be selected by considering options other than replacement, such as refurbishment, spare units strategy adjustment, intensified maintenance, real time monitoring or "doing nothing". This is particularly effective when dealing with proactively replaced assets.
- 9. It is recommended that Horizon Utilities look into implementing an IT solution that will allow them to integrate data and information from different existing data sources, will improve field data collection and storage, will be fully integrated with the work execution process, and will enable automated periodic updating of the ACA results based on the new condition data and/or modified Health Index formulations.

| Horizon Utilities<br>2013 Asset Condition Assessment | VI Appendix A: Results and Findings for Each Asset Category |
|--|---|
|  |   |
|  |   |
|  |   |
|  |   |
| VI APPENDIX A: RESULTS ANI                           | D FINDINGS FOR EACH ASSET CATEGORY                          |
| VI APPENDIX A: RESULTS ANI                           | D FINDINGS FOR EACH ASSET CATEGORY                          |
|  |   |

#### 1 Substation Transformers

While substation power transformers can be employed in either step-up or step-down mode, a majority of the applications in distribution stations involve step down of the transmission or sub-transmission voltage to distribution voltage levels. Power transformers vary in capacity and ratings over a broad range. There are two general classifications of power transformers: transmission station transformers and distribution station transformers. For distribution stations, power transformer ratings typically range from 3 MVA to 30 MVA. The units included in this study range from 3 MVA to 10 MVA.

Power transformers employ many different design configurations, but they are typically made up of the following main components:

- Primary and secondary windings
- Laminated iron core
- Internal insulating mediums
- Main tank
- Bushings
- Cooling system, including radiators, fans and pumps (Optional)
- Off load tap changer (Optional)
- On load tap changer (Optional)
- Instrument transformers
- Control mechanism cabinets
- Instruments and gauges

The primary and secondary windings are installed on a laminated iron core and serve as the coils in which electromotive force is produced when alternating magnetic flux passing through the core links with the windings. The internal insulating mediums provide insulation for energized coils. Insulating oil serves as the insulating medium as well as serves as the coolant. Due to its low cost, high dielectric strength, excellent heat-transfer characteristics, and ability to recover after dielectric overstress, mineral oil is the most widely used transformer insulating material. The transformer coil insulation is reinforced with different forms of solid insulation that include wood-based paperboard (pressboard), wrapped paper and insulating tapes. Because the dielectric strength of oil is approximately half that of the pressboard, the dielectric stress in the oil ends up being higher than that in the pressboard, and the design structure is usually limited by the stress in the oil. The insulation on the conductors of the winding may be enamel or wrapped paper which is either wood or nylon based. The use of insulation directly on the conductor actually inhibits the formation of potentially harmful streamers in the oil, thereby increasing the strength of the structure. Heavy paper wrapping is also usually used on the leads coming from the windings.

The main tank holds the active components of the transformer in an oil volume and maintains a sealed environment through the normal variations of temperature and pressure. Typically, the main tank is designed to withstand a full vacuum for initial and subsequent oil fillings and is able to sustain a positive pressure. The main tank also supports the internal and external components of the transformers. Main tank designs can be classified into 2 types: those being conservator type or sealed type. Conservator types have an externally-mounted tank that usually holds 10% of the main tank's volume. As the transformer oil expands and contracts due

to system loading and ambient changes, the corresponding oil volume change must be accommodated. This tank is used to provide a holding mechanism for the expansion and contraction of the main tank's oil over these temperature variations. The liquid seal also provides some protection against moisture ingress into the insulation systems. A sealed tank design incorporates a gas header on top of the oil volume using nitrogen or dry air. This gas header can be either in a positive pressure or vacuum mode depending on the system loading or ambient changes. The pressure and vacuum conditions of a sealed tank design are controlled by the use of a regulator that ensures the tank is within its design limits.

Bushings are used to facilitate the egress of conductors to connect ends of the coils to a power supply system in an insulated, sealed (oil-tight and weather-tight) manner. A bushing is typically composed of an outer porcelain body mounted on a metallic flange. The phase leads are either independent paper-insulated or are an integral part of the bushing. At higher voltage levels, additional insulation is incorporated in the form of mineral oil and/or wound paper leads installed within the porcelain column.

The purpose of a cooling system in a power transformer is to efficiently dissipate heat generated due to copper and iron losses and to help maintain the windings and insulation temperature within acceptable range. The utilization of a number of cooling stages allows for an increase in load carrying capability. Loss of any stage or cooling element may result in a forced de-rating of the transformer. Transformer cooling system ratings are typically expressed as:

- Self-cooled (radiators) with designation as ONAN (oil natural, air natural)
- Forced cooling first stage (fans) with designation as ONAF (oil natural, air forced)
- Forced cooling second stage (fans and pumps) with designation as OFAF (oil forced, air forced)

An off-load tap changer allows the transformer turns ratio to be altered over a small range to effect changes in output voltage as required. An off-load tap changer typically allows for an adjustment of 5% above nominal and 5% below nominal voltage in 2 ½ % steps. An off-load tap changer must only be operated with the transformer off potential. Under-load tap changers (ULTCs) allow for automatic voltage regulation in response to varying load conditions on the line. ULTCs consist of moving mechanical parts, a drive motor, linkages and voltage regulation sensing equipment. Instrument transformers include CT's and PTs for metering or control purposes. Power transformers are equipped with externally-mounted control cabinets for voltage and current control relay(s), secondary control circuits, and in some cases the tap changer motor and position indicators.

From the view of both financial and operational risk, power transformers are the most important asset deployed on the distribution and transmission systems. A significant proportion of power transformers employed by North American utilities were installed in the 1950s, 1960s or early 1970s. Despite the fact that the number of transformer failures arising due to End-of-Life (EOL) has to-date been relatively small, there is awareness that a majority of the transformer population will soon be reaching its end-of-life, which may significantly impact transformer failure rates.

# 1.1 Substation Transformers Degradation Mechanism

For a majority of transformers, EOL is expected to be spelled by the failure of insulation system and more specifically the failure of pressboard and paper insulation. While the insulating oil can be treated or changed, it is not practical to change the paper and pressboard insulation. The condition and degradation of the insulating oil, however, plays a significant role in aging and deterioration of transformer, as it directly influences the speed of degradation of the paper insulation. The degradation of oil and paper in service in transformers is essentially an oxidation process. The three important factors that impact the rate of oxidation of oil and paper insulation are presence of oxygen, high temperature and moisture.

Transformer oil is made up of complex hydrocarbon compounds, containing anti-oxidation compounds. Despite the presence of oxidation inhibitors, oxidation occurs slowly under normal operating conditions. The rate of oxidation is a function of internal operating temperature and age. The oxidation rate increases as the oil ages, reflecting both the depletion of the oxidation inhibitors and the catalytic effect of the oxidation products on the oxidation reactions. The products of oxidation of hydrocarbons are moisture, which causes further deterioration of the insulation system and organic acids, which result in formation of solids in the form of sludge. Increasing acidity and water levels result in the oil being more aggressive with regard to the paper and hence accelerate the ageing of the paper insulation. Formation of sludge adversely impacts the cooling capability of the transformer and adversely impacts its dielectric strength. An indication of the condition of insulating oil can be obtained through measurements of its acidity, moisture content and breakdown strength.

The paper insulation consists of long cellulose chains. As the paper ages through oxidization, these chains are broken. The tensile strength and ductility of insulting paper are determined by the average length of the cellulose chains; therefore, as the paper oxidizes the tensile strength and ductility are significantly reduced and insulating paper becomes brittle. The average length of the cellulose chains can be determined by measurement of the degree of polymerization (DP). However, this test can be performed only after de-tanking or the core and coil and therefore, is not a practical test. For a new transformer the DP value of the paper is normally greater than 1,000. As the paper ages this figure gradually decreases. When the DP value approaches below 250, the paper is in a very brittle and fragile condition. The lack of mechanical strength of paper insulation can result in failure if the transformer is subjected to mechanical shocks that may be experienced during normal operational situations.

In addition to the general oxidation of the paper, degradation and failure can also result from partial discharge (PD). PD can be initiated if the level of moisture is allowed to develop in the paper or if there are other minor defects within active areas of the transformer.

The relative levels of carbon dioxide and carbon monoxide dissolved in oil can provide an indication of paper degradation. Detection and measurement of Furans in the oil provides a more direct measure of the paper degradation. Furans are a group of chemicals that are created as a bi-product of the oxidation process of the cellulose chains. The occurrence of partial discharge and other electrical and thermal faults in the transformer can be detected and monitored by measurement of hydrocarbon gases in the oil through Dissolved Gas Analysis (DGA).

Oil analysis is such a powerful diagnostic and condition assessment technique that combining it with background information related to the specification, operating history, loading conditions and system-related issues of a transformer provides a very effective means of assessing condition and helps to identify units at high risk of failure. It is the ideal platform on which to base an ongoing management strategy for aging transformers. The analysis helps to identify units that warrant consideration for continued use, makes consideration of remedial measures to extend life and identifies transformers that should be considered for replacement within a defined time frame.

Other condition assessment techniques for power transformers include the use of online monitors capable of monitoring specific parameters, e.g. dissolved gas monitors, continuous moisture measurement or temperature monitoring, winding continuity checks, DC insulation resistance measurements and no load loss measurements. Dielectric measurements that attempt to give an indication of the condition of the insulation system include dielectric loss, dielectric spectroscopy, polarization index and recovery voltage measurements. Doble testing is a procedure that falls within this general group. Other techniques that are commonly applied to transformers include infrared surveys, partial discharge detection and location using ultrasonic and/or electromagnetic detection and frequency response analysis.

Under-load tap changers are prone to failures resulting from either mechanical or electrical degradation. Active maintenance is required for tap changers in order to manage these issues. It is normal practice to maintain tap changers either at a fixed time interval or after a number of operations. During operation, wear of contacts and buildup of oil degradation products, resulting from arcing activity during make and break of contacts, are the primary degradation processes. Maintenance, cleaning/replacement of contacts, defective components in the mechanism and changing/reprocessing of oil are the primary maintenance activities that deal with these issues. Oil analysis for tap changers is considered less useful than oil analysis for transformers due to the generation of gases and general degradation of the oil during arcing under normal ULTC operation.

There are a number of contributory factors to the long life of transformers. In the 1950s and 1960s transformers were designed and manufactured conservatively such that the thermal and electrical stresses, even at high load, were relatively low compared to modern designs. In addition, the loading of many of these transformers has been relatively light during their working life.

Consequences of power transformer failure include customer interruptions over significantly long durations. Catastrophic failure of a transformer may also result in injury or death, fire and damage to property. There are also environmental risks due to oil spills during tank failures. These risks are more pronounced where transformers are located near water bodies or contain PCBs.

#### 1.2 Substation Transformers Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Substation Transformers. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

# 1.2.1 Substation Transformers Condition and Sub-Condition Parameters

Table 1-1 Condition Weights and Maximum CPS

| m | Condition parameter  | WCP <sub>m</sub> | CPS Lookup Table |
|---|----------------------|------------------|------------------|
| 1 | Insulation           | 6                | Table 1-2        |
| 2 | Cooling              | 1                | Table 1-3        |
| 3 | Sealing & connection | 3                | Table 1-4        |
| 4 | Service Record       | 3                | Table 1-5        |

Table 1-2 Insulation (m=1) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Oil Quality             | Table 1-6           | 1                 | 4                    |
| 2 | Oil DGA                 | Table 1-7           | 2                 | 4                    |
| 3 | Bushings                | Table 1-8           | 1                 | 4                    |

Table 1-3 Cooling (m=2) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Cooling Fan             | Table 1-8           | 1                 | 4                    |
| 2 | Cooling Radiators       | Table 1-8           | 2                 | 4                    |

Table 1-4 Sealing & Connection (m=3) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Tank/Conservator        | Table 1-8           | 2                 | 4                    |
| 2 | Gauges                  | Table 1-8           | 2                 | 4                    |
| 3 | Oil Leaks               | Table 1-8           | 5                 | 4                    |
| 4 | Silica Gel              | Table 1-8           | 2                 | 4                    |

Table 1-5 Service Record (m=4) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Performance Record      | Table 1-8           | 1                 | 4                    |
| 2 | Age                     | Figure 1-1          | 3                 | 4                    |

# 1.2.2 Substation Transformers Condition Parameter Criteria

# Oil Quality

**Table 1-6 Oil Quality Test Criteria** 

| CPF | Description                           |  |  |  |  |
|-----|---------------------------------------|--|--|--|--|
| 4   | Overall factor is less than 1.2       |  |  |  |  |
| 3   | Overall factor between 1.2 and 1.5    |  |  |  |  |
| 2   | Overall factor is between 1.5 and 2.0 |  |  |  |  |
| 1   | Overall factor is between 2.0 and 3.0 |  |  |  |  |
| 0   | Overall factor is greater than 3.0    |  |  |  |  |

Where the Overall factor is the weighted average of the following gas scores:

| Oil Quality Test                      | Voltage Class     | Scores |               |              |        |        |  |
|---------------------------------------|-------------------|--------|---------------|--------------|--------|--------|--|
|                                       | [kV]              | 1      | 2             | 3            | 4      | Weight |  |
| Water Content                         | V <u>&lt;</u> 69  | < 30   | 30-35         | 35-40        | > 40   |        |  |
| (D1533)                               | 69 < V < 230      | < 20   | 20-25         | 25-30        | > 35   | 5      |  |
| [ppm]                                 | V <u>&gt;</u> 230 | < 15   | 15-20         | 20-25        | > 25   |        |  |
| Dielectric Strength                   | V <u>&lt;</u> 69  | > 40   | 35-40         | 30-35        | < 30   |        |  |
| (D1816 - 2 mm gap)                    | 69 < V < 230      | > 47   | 42-47         | 35-42        | < 35   |        |  |
| [kV]                                  | V <u>≥</u> 230    | > 50   | 50-45         | 40-45        | < 40   | 4      |  |
| Dielectric Strength<br>(D877)<br>[kV] | All               | > 40   | 30-40         | 20-30        | < 20   | 7      |  |
| IFT                                   | V <u>&lt;</u> 69  | > 25   | 20-25         | 15-20        | < 15   |        |  |
| (D971)                                | 69 < V < 230      | > 30   | 23-30         | 18-23        | < 18   | 4      |  |
| [dynes/cm]                            | V <u>≥</u> 230    | > 32   | 25-32         | 20-25        | < 20   |        |  |
| Color                                 | All               | < 1.5  | 1.5-<br>2.0   | 2.0-2.5      | > 2.5  | 1      |  |
| Acid Number                           | V <u>&lt;</u> 69  | < 0.05 | 0.05-<br>0.01 | 0.1-0.2      | > 0.2  | 4      |  |
| (D974)<br>[mg KOH/g]                  | 69 < V < 230      | < 0.04 | 0.04-<br>0.1  | 0.1-<br>0.15 | > 0.15 | 4      |  |

| Oil Quality Test                     | Voltage Class<br>[kV] | Scores |               |              |       |        |
|--------------------------------------|-----------------------|--------|---------------|--------------|-------|--------|
|                                      |                       | 1      | 2             | 3            | 4     | Weight |
|                                      | V <u>&gt;</u> 230     | < 0.03 | 0.03-<br>0.07 | 0.07-<br>0.1 | > 0.1 |        |
| Dissipation Factor<br>(D924 - 25°C)  | All                   | < 0.5% | 0.5%-<br>1%   | 1-2%         | > 2%  | 5      |
| Dissipation Factor<br>(D924 - 100°C) | All                   | < 5%   | 5%-<br>10%    | 10%-<br>20%  | > 20% | 3      |

For example if all data is available, overall Factor = 
$$\frac{\sum Score_i \times Weight_i}{12}$$

#### Oil DGA

**Table 1-7 Oil DGA Criteria** 

| CPF | Description                               |  |  |  |  |
|-----|---|--|--|--|--|
| 4   | DGA overall factor is less than 1.2       |  |  |  |  |
| 3   | DGA overall factor between 1.2 and 1.5    |  |  |  |  |
| 2   | DGA overall factor is between 1.5 and 2.0 |  |  |  |  |
| 1   | DGA overall factor is between 2.0 and 3.0 |  |  |  |  |
| 0   | DGA overall factor is greater than 3.0    |  |  |  |  |

<sup>\*</sup>In the case of a score other than 4, check the variation rate of DGA parameters. If the maximum variation rate (among all the parameters) is greater than 30% for the latest 3 samplings or 20% for the latest 5 samplings, overall Health Index is multiplied by 0.9 for score 3, 0.85 for score 2, 0.75 for score 1 and 0.5 for score 0 where the DGA overall factor is the weighted average of the following gas scores:

2.5 MVA to 10 MVA

| Dissolved Gas   | Scores  |           |            |          |          |       |        |
|-----------------|---------|-----------|------------|----------|----------|-------|--------|
| Dissolved Gas   | 1       | 2         | 3          | 4        | 5        | 6     | Weight |
| H2              | <=70    | <=100     | <=200      | <=400    | <=1000   | >1000 | 4      |
| CH4(Methane)    | <=70    | <=120     | <=200      | <=400    | <=600    | >600  | 3      |
| C2H6(Ethane)    | <=75    | <=100     | <=150      | <=250    | <=500    | >500  | 3      |
| C2H4(Ethylene)  | <=60    | <=100     | <=150      | <=250    | <=500    | >500  | 3      |
| C2H2(Acetylene) | <=3     | <=7       | <=35       | <=50     | <=100    | >100  | 5      |
| CO2/CO          | 3 to 10 | <=10to 12 | <=12 to 15 | 15 to 18 | 18 to 20 | >20   | 4      |

#### Age

Assume that the failure rate for Substation Transformers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function

 $P_f$  = probability of failure

Assuming that at the ages of 45 and 60 years the probability of failures ( $P_f$ ) for this asset are 20% and 85% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below.

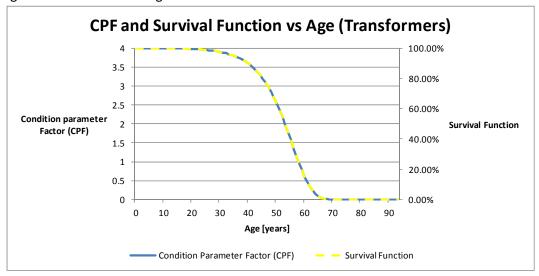


Figure 1-1 Substation Transformers Age Condition Criteria

## **Station Inspections**

**Table 1-8 Inspection Condition Criteria** 

| CPF | Condition Description (Horizon Grading) |  |  |
|-----|---|--|--|
| 4   | Good                                    |  |  |
| 2   | Fair                                    |  |  |
| 0   | Poor                                    |  |  |

# 1.3 Substation Transformers Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 44 years.

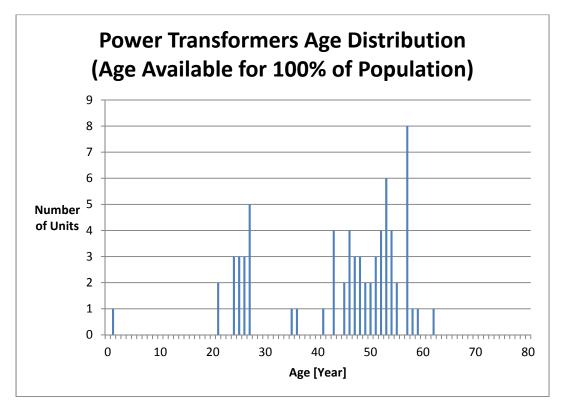


Figure 1-2 Substation Transformers Age Distribution

## 1.4 Substation Transformers Health Index Results

There are 70 in-service Substation Transformers at Horizon Utilities. Of these, 70 units had sufficient data for assessment.

The average Health Index for this asset group is 86%. None of the units were found to be in poor condition.

The Health Index Distribution is shown in Figure 1-3 and Figure 1-4.

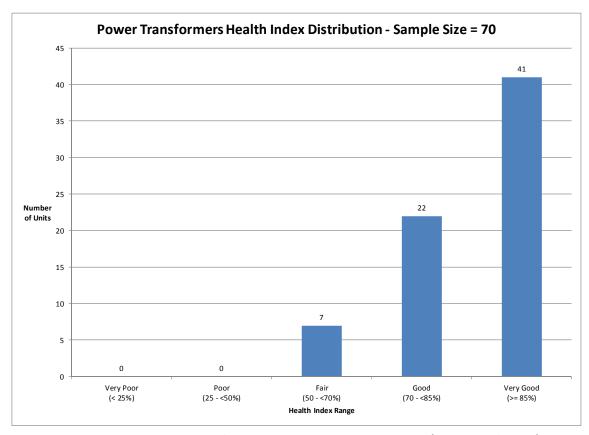


Figure 1-3 Substation Transformers Health Index Distribution (Number of Units)

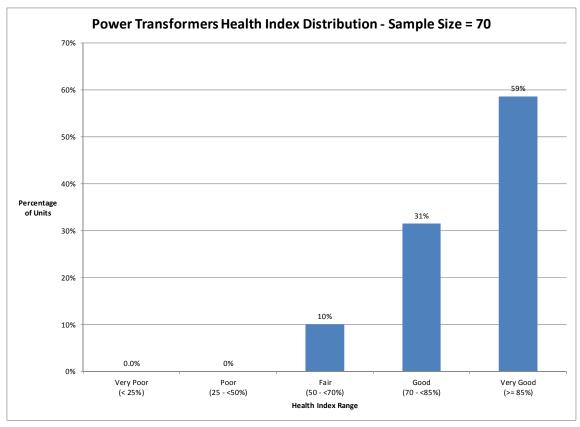


Figure 1-4 Substation Transformers Health Index Distribution (Percentage of Units) The detailed results, from lowest to highest Health Index are shown in section VII.

### 1.5 Substation Transformers Condition-Based Flagged-For-Action Plan

As it is assumed that Substation Transformers are proactively replaced, the risk assessment and replacement procedure described in Section II.2.3 was applied for this asset class.

As noted in Section II.2.3, a unit becomes a candidate for replacement when its risk, product of its *probability of failure* and *criticality*, is greater than or equal to a calculated risk limit. The probability of failure is as determined by the Health Index. Criticality is determined as shown in the following section.

### 1.5.1 Substation Transformers Criticality

The minimum criticality, Criticality<sub>min</sub>, is 1.25. The maximum criticality, Criticality<sub>max</sub>, is twice the base criticality (Criticality<sub>max</sub>, = 1.25\*2 = 2.5).

Each unit's criticality is defined as follows:

Criticality =  $(Criticality_{max} - Criticality_{min})*Criticality_Multiple + Criticality_{min}$ 

where the Criticality\_Multiple (CM) is defined by criticality factors, weights, and scores:

$$CM = \frac{\sum_{CF=1}^{\forall CF} (CFS_{CF} \times WCF_{CF})}{\sum_{CF=1}^{\forall CF} (WCF_{CF})}$$

Where

CFS Criticality Factor Score
WCF Weight of Condition Factor

The factors, weights and the score system of each factor are as follows:

**Table 1-9 Criticality Factors** 

| Criticality Factor (CF) Description |  | Weight<br>(WCF) | Score | e (CFS) |
|-------------------------------------|--|-----------------|-------|---------|
| Lood oriticality                    | Number of customers Customer importance (e.g.  | 20              | Low   | 0       |
| Load criticality                    | hospitals, provincial buildings, restoration time sensitive customers)                           | 30              | High  | 1       |
| Dhysical Drotostics                 | oil containment, blast wall,   | 15              | Yes   | 0       |
| Physical Protection                 | deluge system  | 15              | No    | 1       |
| Location                            | public exposure,   | 15              | No    | 0       |
| LOCATION                            | environmental impact   |                 | Yes   | 1       |
| Eveneted Outage Duration            | Back-up unit unavailable,  | 20              | No    | 0       |
| Expected Outage Duration            | alternate feeds unavailable  | 20              | Yes   | 1       |
|                                     | obsolescence of spare parts (e.g. manufacturers cease to   |                 | No    | 0       |
| Operation & Maintenance             | produce old types of spare parts) known issues (e.g. not economical to have routine maintenance) | 20              | Yes   | 1       |

# 1.5.2 Substation Transformers Flagged-For-Action Plan

The following diagram shows the flagged for action plan in the next 20 years.

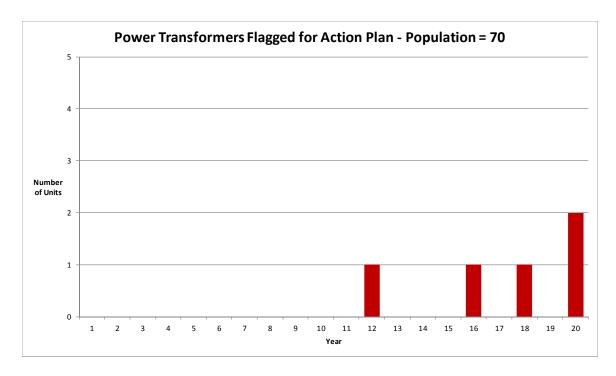


Figure 1-5 Substation Transformers Condition-Based Flagged-For-Action Plan

## 1.6 Substation Transformers Data Analysis

The data available for Substation Transformers includes age, routine inspection results, oil quality, dissolved gas analysis (DGA), and third party inspection records.

Horizon Utilities should start collecting DGA data for individual gases in order to be able to establish the rate of increase in them which, in addition to the absolute values of gasses in oil, serves as a good indicator of transformer's insulation condition. This will also allow Horizon Utilities to modify formulation and flag-for-action units where only quantities of some specific gases have shown a higher than acceptable rate of increase.

#### 2 Substation Circuit Breakers

Circuit breakers used in transmission and distribution power systems to sectionalize and isolate circuits are often categorized by the insulation medium used in the breaker and the interruption process. The common breaker types include oil circuit breakers, air circuit breakers, vacuum circuit breakers, and SF6 circuit breakers.

Oil circuit breakers (OCB) have been in use for over 70 years. OCBs interrupt current under oil and use the gas generated by the decomposition of the oil to assist in arc extinguishing. They are available in single or multi-tank configurations. Two types of designs exist among OCBs: bulk oil breakers (in which oil serves as the insulating and arc quenching medium), and minimum oil breakers (in which oil provides the arc quenching function only). OCBs are available from 25kV class and up, with continuous currents up to 1200A and interrupting capacities up to 40kA.

Air insulated breakers are generally used at distribution system voltages and below. Air-type circuit breakers fall into two classifications: air- blast and air- magnetic. Air-blast breakers use compressed air as the quenching, insulating and actuating mechanism. In a typical device a blast of air carries the arc into an arc chute to be extinguished. Air blast breakers at distribution voltages are often in metal-enclosed switchgear. Continuous current ratings of these devices are in the range of 1200 to 5000 A, and fault interrupting from 20 to 140kA.

Air magnetic breakers use the magnetic effect of the current undergoing interruption to draw an arc into an arc chute for cooling, splitting and extinction. Sometimes, an auxiliary puffer or air blast piston may help interrupt low-level currents. These designs are commonly used in metal-clad switchgear applications. Air magnetic breakers are available in voltages ratings up to 15kV, with continuous currents up to 3000A, and interrupting ratings as high as 40 kA. These breakers are relatively inexpensive and relatively easy to maintain. The air magnetic breakers have short duty cycles, require frequent maintenance and approach their end-of-life at much faster rates than either SF6 or vacuum breakers. They also have limited transient recovery voltage capabilities and can experience re-strike when switching capacitive currents.

In vacuum breakers, the parting contacts are placed in an evacuated chamber (i.e. bottle). There is generally one fixed and one moving contact in a butting configuration. A bellows attached to the moving contact permits the required short stroke to occur while maintaining the vacuum. Arc interruption occurs at current zero after withdrawal of the moving contact. Utilities typically install vacuum breakers indoors in metal-clad switchgear. Current medium voltage vacuum breakers require low mechanical drive energy, have high endurance, can interrupt fully rated short circuits up to 100 times, and operate reliably over 30,000 or more switching operations. Vacuum breakers also are safe and protective of the environment.

SF6 Circuit breakers were first developed in the late 1960s and based on air blast technology. SF6 breakers interrupt currents by opening a blast valve and allowing high pressure SF6 to flow through a nozzle along the arc drawn between fixed and moving contacts. This process rapidly deionizes, cools and interrupts the arc. After interruption, low-pressure gas is compressed for re-use in the next operation.

### 2.1 Substation Circuit Breakers Degradation Mechanism

In general, circuit breakers have many moving parts that are subject to wear and stress. They frequently "make" and "break" high currents and experience the erosion caused by arcing accompanying these operations. All circuit breakers undergo some contact degradation every time they open to interrupt an arc. Also, arcing produces heat and decomposition products that degrade surrounding insulation materials, nozzles, and interrupter chambers. The mechanical energy needed for the high contact velocities of these assets adds mechanical deterioration to their degradation processes.

The rate and severity of degradation depends on many factors, including insulating and conducting materials, operating environments, and a breaker's specific duties. Outdoor circuit breakers may experience adverse environmental conditions that influence their rate and severity of degradation. For outdoor mounted circuit breakers, the following represent additional degradation factors:

- Corrosion
- Effects of moisture
- Bushing/insulator deterioration
- Mechanical

Corrosion and moisture commonly cause degradation of internal insulation, breaker performance mechanisms, and major components like bushings, structural components, and oil seals. Corrosion presents problems for almost all circuit breakers, irrespective of their location or housing material. Rates of corrosion degradation, however, vary depending on exposure to environmental elements. Underside tank corrosion causes problem in many types of breakers, particularly those with steel tanks. Another widespread problem involves corrosion of operating mechanism linkages that result in eventual link seizures. Corrosion also causes damage to metal flanges, bushing hardware and support insulators.

Moisture causes degradation of the insulating system. Outdoor circuit breakers experience moisture ingress through defective seals, gaskets, pressure relief and venting devices. Moisture in the interrupter tank can lead to general degradation of internal components. Also, sometimes free water collects in tank bottoms, creating potential catastrophic failure conditions.

For circuit breakers, mechanical degradation presents greater end-of-life concerns than electrical degradation. Generally, operating mechanisms, bearings, linkages, and drive rods represent components that experience most mechanical degradation problems. Oil leakage also occurs. Contacts, nozzles, and highly stressed components can also experience electrical-related degradation and deterioration. Other effects that arise with aging include:

- Loose primary and grounding connections
- Oil contamination and/or leakage
- Deterioration of concrete foundation affecting stability of breaker

For OCBs, the interruption of load and fault currents involves the reaction of high pressure with large volumes of hydrogen gas and other arc decomposition products. Thus, both contacts and

oil degrade more rapidly in OCBs than they do in vacuum designs, especially when the OCB undergoes frequent switching operations. Generally, 4 to 8 fault interruptions with contact erosion and oil carbonization will lead to the need maintenance, including oil filtration. Oil breakers can also experience restrike when switching low load or line charging currents with high recovery voltage values. Sometimes this can lead to catastrophic breaker failures.

The diagnostic tests to assess the condition of circuit breakers include:

- Visual inspections
- Travel time tests
- Contact resistance measurements
- Bushing Doble Test
- Stored energy tests (Air/Hydraulic/Spring Recharge Time)
- Insulating medium tests

As indicated above, the useful life of circuit breakers can vary significantly depending on the duty cycle and typically lies within a broad range of 25 to 50 years.

In some cases, the end of life for circuit breakers may not be governed by technical considerations but rather by operational, maintenance and obsolescence issues. The International Council on Large Electric Systems' (CIGRE) has identified the following factors that lead to end-of-life for this asset class:

- Decreasing reliability, availability and maintainability
- High maintenance and operating costs
- Changes in operating conditions, rendering the existing asset obsolete;
- Maintenance overhaul requirements; and

Consequences of circuit breaker failure may be significant as they can directly lead to catastrophic failure of the protected equipment, leading to customer interruptions, health and safety consequences and adverse environmental impacts.

#### 2.2 Substation Circuit Breakers Health Index Formula

This section presents the Health Index Formula that was developed and used for Horizon Utilites' Circuit Breakers. The Health Index equation is shown in Section II.1; the condition, subcondition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 2.2.1 Substation Circuit Breakers Condition and Sub-Condition Parameters

Table 2-1 Substation Circuit Breakers Condition Weights and Maximum CPS

|   | Condition negotian  | WCP <sub>m</sub>               |     | CDC Lookun Toblo |  |
|---|---------------------|--------------------------------|-----|------------------|--|
| m | Condition parameter | Oil                            | Air | CPS Lookup Table |  |
| 1 | Contact performance | 7                              | 7   | Table 2-2        |  |
| 2 | Arc extinction      | 9                              | 5   | Table 2-3        |  |
| 3 | Service Record      | 5 5                            |     | Table 2-4        |  |
|   | Derating Factor     | As a multiplier for overall HI |     | Table 2-6        |  |

Table 2-2 Substation Circuit Breakers Contact Performance (m=1) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF lookup table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|------------------|-------------------|----------------------|
| 1 | Primary contact         | Table 2-5        | 1                 | 4                    |
| 2 | Trip coil               | Table 2-5        | 2                 | 4                    |
| 3 | Contact Resistance      | Table 2-5        | 1                 | 4                    |

Table 2-3 Substation Circuit Breakers Arc Extinction (m=2) Weights and Maximum CPF

|   | Sub-Condition CPF lookup |           | o-Condition CPF lookup WCPF <sub>n</sub> |     |                      |
|---|--------------------------|-----------|--|-----|----------------------|
| n | Parameter                | table     | Oil                                      | Air | CPF <sub>n.max</sub> |
| 1 | Tank                     | Table 2-5 | 1  | 1   | 4                    |
| 3 | Arc chute                | Table 2-5 | 2  | 2   | 4                    |
| 4 | Oil condition            | Table 2-5 | 4  |     | 4                    |

Table 2-4 Substation Circuit Breakers Service Record (m=3) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|---------------------|-------------------|----------------------|
| 1 | CB operation               | Table 2-5           | 2                 | 4                    |
| 2 | CB performance record      | Table 2-5           | 1                 | 4                    |
| 3 | Age                        | Figure 2-1          | 1                 | 4                    |

### 2.2.2 Substation Circuit Breakers Condition Parameter Criteria

## **Station Inspections**

**Table 2-5 Substation Circuit Breakers Inspection Condition Criteria** 

| CPF Condition Description (Horizon Grading) |      |  |
|---|------|--|
| 4   | Good |  |
| 2   | Fair |  |
| 0   | Poor |  |

### <u>Age</u>

Assume that the failure rate for circuit breakers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 45 and 60 years the probabilities of failure ( $P_f$ ) are 20% and 85% result in the survival curves shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below.

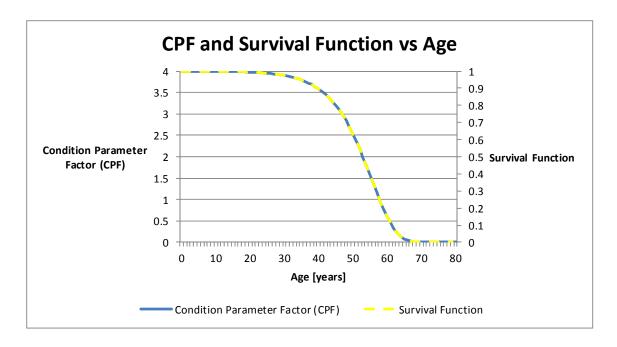


Figure 2-1 CPF and Survival Function vs. Age (Circuit Breakers)

# **Derating Factor**

The de-rating is based on the following equation:

$$DR = DRF_1$$

Equation 2-1

Where DRF are as described in Table 2-6

**Table 2-6 Substation Circuit Breakers De-Rating Factors** 

| De-<br>Rating<br>Factor<br>(DRF) | De-Rating Factor | Description   |
|----------------------------------|------------------|---|
| DRF <sub>1</sub>                 | 0.3              | All the oil circuit breakers, due to closing timing and safety issues |

# 2.3 Substation Circuit Breakers Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 28 years.

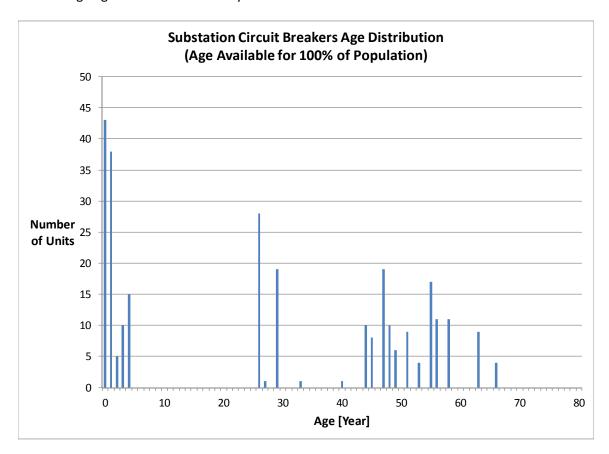


Figure 2-2 Substation Circuit Breakers Age Distribution

# 2.4 Substation Circuit Breakers Health Index Results

There are 279 in-service Substation Circuit Breakers at Horizon Utilities. All of them have data for assessment.

The average Health Index for this asset group is 77%. Approximately 23% of the units were found to be in poor or very poor condition.

The Health Index Distribution is shown in Figure 1-3 and Figure 1-4.

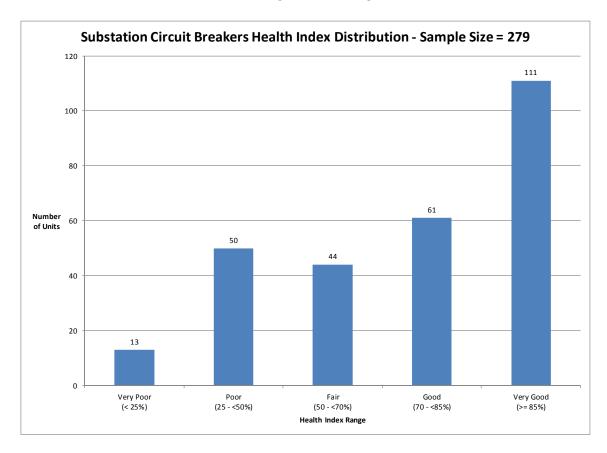


Figure 2-3 Substation Circuit Breakers Health Index Distribution (Number of Units)

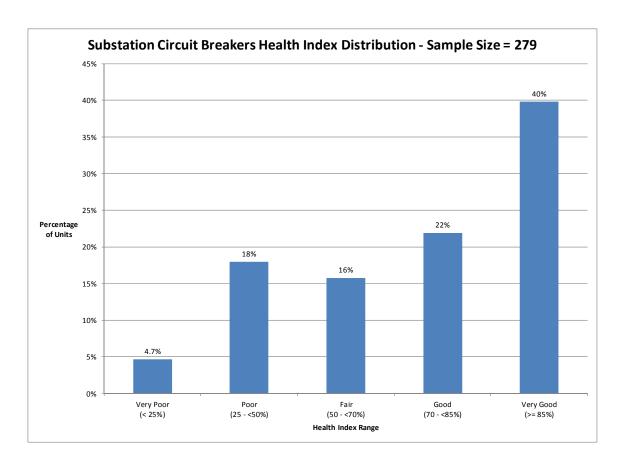


Figure 2-4 Substation Circuit Breakers Health Index Distribution (Percentage of Units)

The detailed results, from lowest to highest Health Index are shown in section VII.

## 2.5 Substation Circuit Breakers Condition-Based Flagged-For-Action Plan

As it is assumed that Substation Circuit Breakers are proactively replaced, the risk assessment and replacement procedure described in Section II.2.3 was applied for this asset class.

As noted in Section II.2.3, a unit becomes a candidate for replacement when its risk, product of its *probability of failure* and *criticality*, is greater than or equal to a calculated risk limit. The probability of failure is as determined by the Health Index. Criticality is determined as shown in the following section.

## 2.5.1 Substation Circuit Breakers Criticality

The minimum criticality, Criticality<sub>min</sub>, is 1.25. The maximum criticality, Criticality<sub>max,</sub> is twice the base criticality (Criticality<sub>max,</sub> = 1.25\*2 = 2.5).

Each unit's criticality is defined as follows:

 $Criticality = (Criticality_{max} - Criticality_{min})*Criticality\_Multiple + Criticality_{min})*Criticality\_Multiple + Criticality_{min})*Criticality\_Multiple + Criticality_{min})*Criticality\_Multiple + Criticality_{min})*Criticality\_Multiple + Criticality_{min})*Criticality\_Multiple + Criticality\_Multiple + Criticali$ 

where the Criticality\_Multiple (CM) is defined by criticality factors, weights, and scores:

$$CM = \frac{\sum_{CF=1}^{\forall CF} (CFS_{CF} \times WCF_{CF})}{\sum_{CF=1}^{\forall CF} (WCF_{CF})}$$

Where

CFS Criticality Factor Score
WCF Weight of Condition Factor

The factors, weights and the score system of each factor are as follows:

**Table 2-7 Substation Circuit Breakers Criticality Factors** 

| Criticality Factor (CF) | Description  | Weight<br>(WCF) | Score | e (CFS) |
|-------------------------|--|-----------------|-------|---------|
|                         | Number of customers  |                 | Low   | 0       |
| Load criticality        | Customer importance (e.g. hospitals, provincial buildings, restoration time sensitive customers) | 25              | High  | 1       |
|                         | system upgrading   |                 | No    | 0       |
| Long-term Development   | (e.g. higher voltage level,<br>higher fault duty to be<br>implemented)                           | 20              | Yes   | 1       |
|                         | obsolescence of spare parts (e.g. manufacturers cease to   |                 | No    | 0       |
| Operation & Maintenance | produce old types of spare parts) known issues (e.g. not economical to have routine maintenance) | 20              | Yes   | 1       |
|                         | Legislation/standard requirement (e.g. replace   |                 | No    | 0       |
| Environmental & Safety  | SF6, oil CBs) Safety concern (e.g. arc resistance feature, remote racking feature)               | 35              | Yes   | 1       |

## 2.5.2 Substation Circuit Breakers Flagged-For-Action Plan

The condition-based Flagged-For-Action Plan for Substation Circuit Breakers is plotted in Figure 2-5.

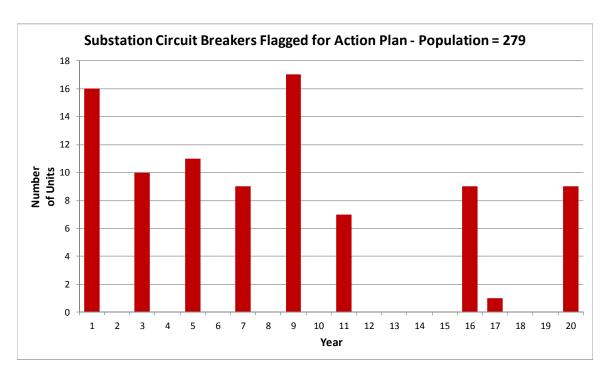


Figure 2-5 Substation Circuit Breakers Condition-Based Flagged-For-Action Plan

## 2.6 Substation Circuit Breakers Data Analysis

The data available for Substation Circuit Breakers includes age and third party inspection.

While keeping with data acquisition from the existing maintenance program, it is suggested that Horizon Utilities resume collecting and storing in electronic format breaker timing test results while continuing with qualitative assessment of resistance performed by a third party.

VI - Appendix A: Results and Findings for Each Asset Category

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# 3 Substation Switchgear

Substation Switchgear consists of an assembly of retractable/racked switchgear devices that are totally enclosed in a metal envelope (metal-enclosed). These devices operate in the medium voltage range, from 4.16 to 34 kV. The switchgear includes breakers, disconnect switches, or fuse gear, current transformers (CTs), potential transformers (PTs) and occasionally some or all of the following: metering, protective relays, internal DC and AC power, battery charger(s), and AC station service transformation. The gear is modular in that each breaker is enclosed in its own metal envelope (cell). The gear also is compartmentalized with separate compartments for breakers, control, incoming/outgoing cables or bus duct, and bus-bars associated with each cell.

#### 3.1 Substation Switchgear Degradation Mechanism

Switchgear degradation is a function of a number of different factors: mechanism operation and performance, degradation of solid insulation, general degradation/corrosion, environmental factors, or post fault maintenance (condition of contacts and arc control devices). Degradation of the breaker used is also a factor. However the degradation mechanism differs slightly between switchgear types: air insulated and gas insulated.

Correct operation of the mechanism is critical in devices that make or break fault currents, i.e. the contact opening and closing characteristics must be within specified limits. The greatest cause of mal-operation of switchgear is related to mechanism malfunction. Deterioration due to corrosion or wear due to lubrication failure may compromise mechanism performance by either preventing or slowing down the operation of the breaker. This is a serious issue for all types of switchgear.

In older air filled equipment, degradation of active solid insulation (for example drive links) has been a significant problem for some types of switchgear. Some of the materials used in this equipment, particularly those manufactured using cellulose-based materials (pressboard, SRBP, laminated wood) are susceptible to moisture absorption. This results in a degradation of their dielectric properties that can result in thermal runaway or dielectric breakdown. An increasingly significant area of solid insulation degradation relates to the use of more modern polymeric insulation. Polymeric materials, which are now widely used in switchgear, are very susceptible to discharge damage. These electrical stresses must be controlled to prevent any discharge activity in the vicinity of polymeric material. Failures of relatively new switchgear due to discharge damage and breakdown of polymeric insulation have been relatively common over the past 15 years.

Temperature, humidity and air pollution are also significant degradation factors, so indoor units tend to have better long-term performance. The safe and efficient operation of switchgear and its longevity may all be significantly compromised if the station environment is not adequately controlled. In addition, the air switchgear can tolerate less number of full fault operations before maintenance is required.

## 3.2 Substation Switchgear Health Index Formula

This section presents the Health Index Formula that was developed and used for Horizon Utilities Substation Switchgear. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

# **3.2.1** *Substation Switchgear Condition and Sub-Condition Parameters*

**Table 3-1 Substation Switchgear Condition and Weights** 

| m | <b>Condition Parameter</b> | WCP <sub>m</sub> | Sub-Condition<br>Parameters |
|---|----------------------------|------------------|-----------------------------|
| 1 | Enclosure Condition        | 2                | Table 3-2                   |
| 2 | Bus & cable compartment    | 3                | Table 3-3                   |
| 3 | Low voltage compartment    | 2                | Table 3-4                   |
| 4 | Service record             | 3                | Table 3-5                   |

Table 3-2 Substation Switchgear Breaker Compartment (m=1) Sub-Conditions and Weights

| n | Sub-condition parameter | WCPF <sub>n</sub> | Condition Criteria Table |
|---|-------------------------|-------------------|--------------------------|
| 1 | Metal Clad              | 1                 | Table 3-6                |
| 2 | Partial Discharge       | 2                 | Table 3-6                |

Table 3-3 Substation Switchgear Bus & Cable Compartment (m=2) Sub-Conditions and Weights

| n | Sub-condition parameter | WCPF <sub>n</sub> | Condition Criteria Table |
|---|-------------------------|-------------------|--------------------------|
| 1 | Cable Terminations      | 2                 | Table 3-6                |
| 2 | Instrument Transformers | 3                 | Table 3-6                |
| 3 | Bus & Insulator         | 2                 | Table 3-6                |

Table 3-4 Substation Switchgear Low Voltage Compartment (m=3) Sub-Conditions and Weights

| n | Sub-condition parameter | WCPF <sub>n</sub> | <b>Condition Criteria Table</b> |  |
|---|-------------------------|-------------------|---------------------------------|--|
| 1 | Relays                  | 3                 | Table 3-6                       |  |
| 2 | RTU                     | 2                 | Table 3-6                       |  |
| 3 | Batteries               | 1                 | Table 3-6                       |  |
| 4 | Charger                 | 1                 | Table 3-6                       |  |

Table 3-5 Substation Switchgear Service Record (m=3) Sub-Conditions and Weights

| n | Sub-condition parameter       | WCPF <sub>n</sub> | Condition Criteria Table |
|---|-------------------------------|-------------------|--------------------------|
| 1 | Switchgear performance record | 2                 | Table 3-6                |
| 2 | Age                           | 1                 | Figure 3-1               |

### 3.2.2 Substation Switchgear Condition Parameter Criteria

#### **Station Inspection**

**Table 3-6 Substation Switchgear Inspection criteria** 

| CPF | Condition Description (Horizon Grading) |  |
|-----|---|--|
| 4   | Good                                    |  |
| 2   | Fair                                    |  |
| 0   | Poor                                    |  |

### Age

Assume that the failure rate for circuit breakers exponentially increases with age and that the failure rate equation is as follows:

$$f=e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 45 and 60 years the probabilities of failure ( $P_f$ ) are 20% and 85% result in the survival curves shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below.

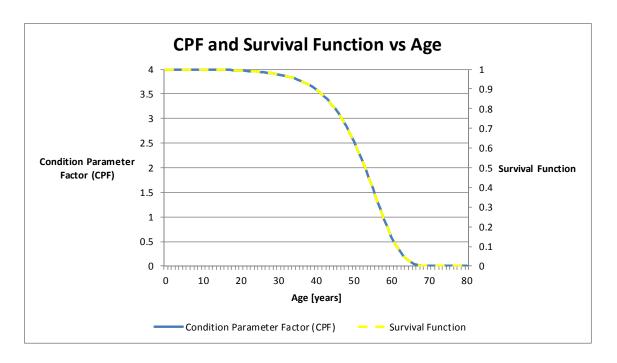


Figure 3-1 CPF and Survival Function vs. Age (Station Switchgear)

# 3.3 Substation Switchgear Age Distribution

The age distribution is shown in the figure below. Age was available for 97% of the population. The average age was found to be 44 years.

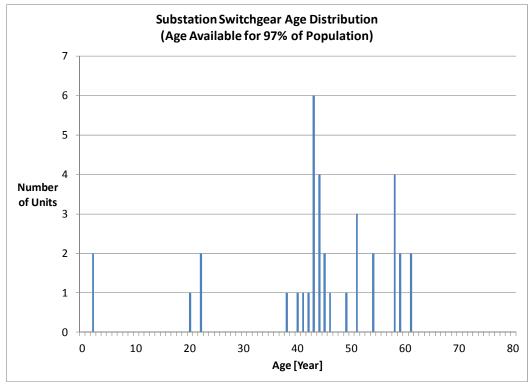


Figure 3-2 Substation Switchgear Age Distribution

# 3.4 Substation Switchgear Health Index Results

There are 42 in-service Substation Switchgear at Horizon Utilities. All of them have data for assessment.

The average Health Index for this asset group is 59%. None of the units were in very poor condition. Approximately 32% of the units were found to be in poor condition.

The Health Index Distribution is shown in Figure 3-3 and Figure 3-4.

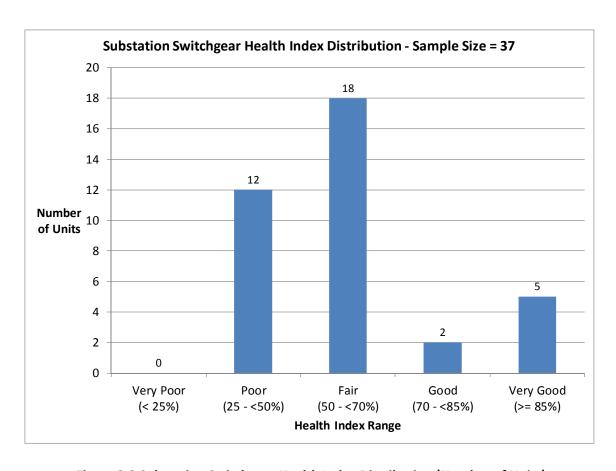


Figure 3-3 Substation Switchgear Health Index Distribution (Number of Units)

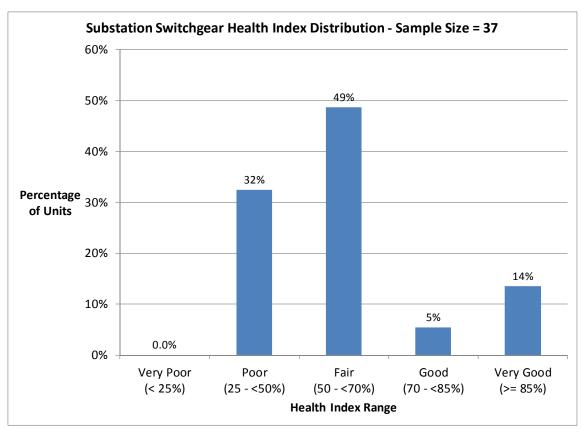


Figure 3-4 Substation Switchgear Health Index Distribution (Percentage of Units)

### 3.5 Substation Switchgear Condition-Based Flagged-For-Action Plan

As it is assumed that Substation Switchgear is proactively replaced, the risk assessment and replacement procedure described in Section II.2.3 was applied for this asset class based on Health Index only, i.e. not including criticality assessment.

The Flagged-For-Action Plan is based on the years when the Health Index based probability of failure reaches 80% for asset units. In this case, the number refers to the bus-section assembly, which consists of multiple switch cells or cabinets. The following diagram shows such a flagged-for-action plan.

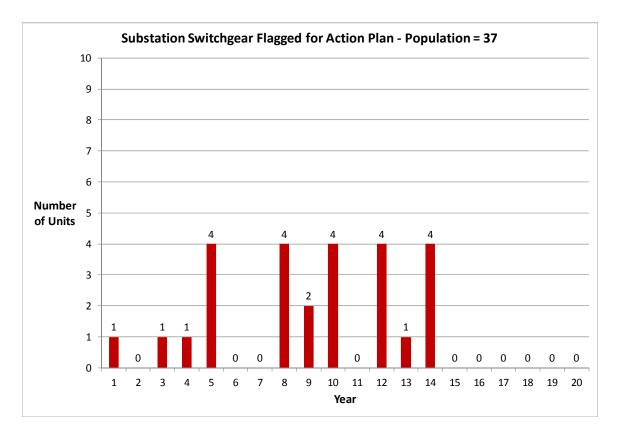


Figure 3-5 Substation Switchgear Condition-Based Flagged-For-Action Plan

# 3.6 Substation Switchgear Data Analysis

The data available for Substation Switchgear includes age and third party inspection records. Horizon Utilities should continue with the existing data collection practices.

VI - Appendix A: Results and Findings for Each Asset Category

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# 4 Pole Top Transformers

Pole-mounted distribution transformers convert power from the distribution primary line voltage to 120\240V utilization voltage employed by the customer. Single-phase pole-mounted transformers are commonly available in ratings from 5kVA to 167kVA but can be as high as 500kVA. They are available in voltages from 4.16\2.4kV to 34.5\19kV. Pole-mounted transformers are generally contained in cylindrical cans filled with insulating oil. The connection to the high voltage source is via a bushing, usually on the top of the unit. The transformer core is generally a wrapped sheet-type steel. Wound copper high voltage windings and sheet-type low voltage windings are wound concentrically on the core. Distribution transformers are self-cooled by air and occasionally have external cooling fins. Typically, pole-mounted transformers of size 100kVA and below are attached directly to the pole whereas higher ratings are mounted on crossbeams.

### 4.1 Pole Top Transformers Degradation Mechanism

Degradation of pole top transformers can occur due to the following mechanisms:

- Corrosion of the tank
- Deterioration or breakage of the bushings
- Deterioration of internal switching or fusing devices
- Degradation of internal insulating material
- Degradation of oil

Tank corrosion can be problematic for overhead transformers particularly in areas of high contamination. Porcelain bushings can develop mechanical cracks or can be subject to breakage due to mechanical vibration and forces. Deterioration of the pole-mounted transformer can also be due to problems such as: breakage of switches and leakage of under-oil fuses.

The life of the transformer's internal insulation is related to temperature-rise and duration. Therefore, transformer life is affected by electrical loading profiles and length of service life. The impacts of loading profiles, load growth, and ambient temperature on asset condition, loss-of-life, and life expectancy can be assessed using methods outlined in ANSI\IEEE Loading Guides. This also provides an initial baseline for the size of transformer that should be selected for a given number and type of customers to obtain optimal life. Insulation condition can also be affected by voltage and current surges.

Distribution pole-mounted transformers sometimes require replacement because of non-condition related factors such as customer load growth, pole replacement or road widening. If a transformer is simply overloaded, a decision is required whether to keep the transformer as spare or to scrap it. Many utilities make this decision through a cost-benefit analysis, by taking into consideration anticipated remaining life of transformer, cost of equivalent-sized new transformer, labour cost for transformer replacement and rated losses of the older transformer in comparison to the newer designs.

Visual inspections provide considerable information on transformer asset condition. Leaks, rusting, and deteriorated connectors can all be established by visual inspections. Transformer oil testing can be employed for distribution transformers to assess the condition of solid and liquid insulation.

The consequences of distribution transformer degradation can be severe if it results in an eventful failure. Though rare, pole-mounted transformers can fail with sufficient energy release to rupture the tank and release oil into the surrounding environment.

### 4.2 Pole Top Transformers Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Pole Top Transformers. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 4.2.1 Pole Top Transformers Condition and Sub-Condition Parameters

Table 4-1 Pole Top Transformers Condition Weights and Maximum CPS

| m | Condition Parameter | WCP <sub>m</sub> | CPS Lookup Table |
|---|---------------------|------------------|------------------|
| 1 | Service Record      | 1                | Table 4-2        |

Table 4-2 Pole Top Transformers Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Loading                    | Table 4-3        | 1                 | 4                    |
| 2 | Age                        | Figure 4-1       | 2                 | 4                    |

# 4.2.2 Pole Top Transformers Condition Parameter Criteria

### Age

Assume that the failure rate for Pole Top Transformers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 40 and 55 years the probability of failure ( $P_f$ ) for this asset are 10% and 90% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

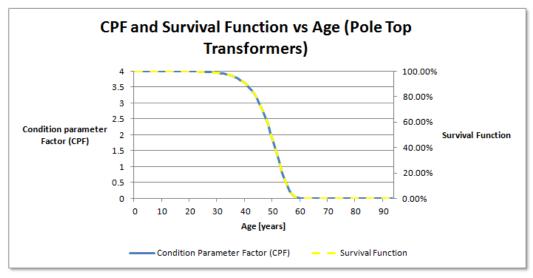


Figure 4-1 Age Condition Criteria (Pole Top Transformers)

### Loading

**Table 4-3 Pole Top Transformers Loading History** 

Data: S1, S2, S3, ..., SN recorded data (monthly 15 min peak)

SB= rated MVA

NA=Number of Si/SB which is lower than 1.0

NB= Number of Si/SB which is between 1 and 1.2

NC= Number of Si/SB which is greater than 1.2

$$\mathsf{CPF} = \frac{NA \times 4 + NB \times 1 + NC \times 0}{N}$$

Hourly transformer loading was used to determine overloading occurrences leading to a loss of life and thereby increasing the effective age of the transformer. Transformer loading was not determined to decrease the effective age of the transformer in the absence of overloading occurrences. Therefore, loading condition was incorporated only when the loading CPF score was less than age CPF score for a transformer. In the cases when age CPF score was lower than that of loading, Health Index was calculated based on age only.

### 4.3 Pole Top Transformers Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 24 years.

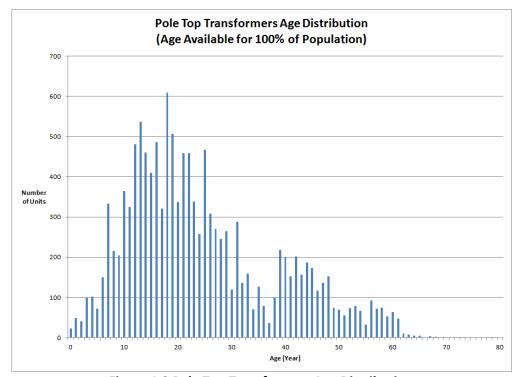


Figure 4-2 Pole Top Transformers Age Distribution

## 4.4 Pole Top Transformers Health Index Results

There are 12886 in-service Pole Top Transformers at Horizon Utilities. The condition assessment is based on age, together with overloading condition calculated using hourly data obtained from Horizon Utilities Smart Meters.

The average Health Index for this asset group is 91%. About 6% of the units were found to be in poor or very poor condition.

The Health Index Results are as follows:

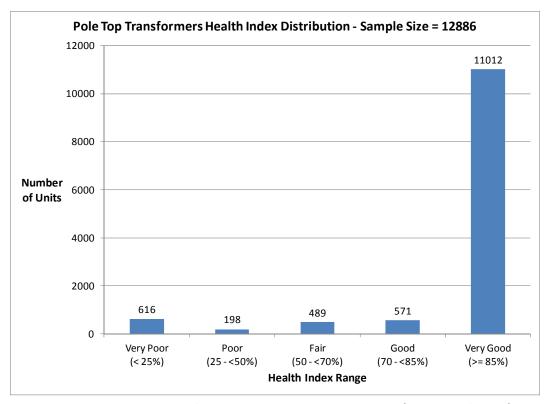


Figure 4-3 Pole Top Transformers Health Index Distribution (Number of Units)

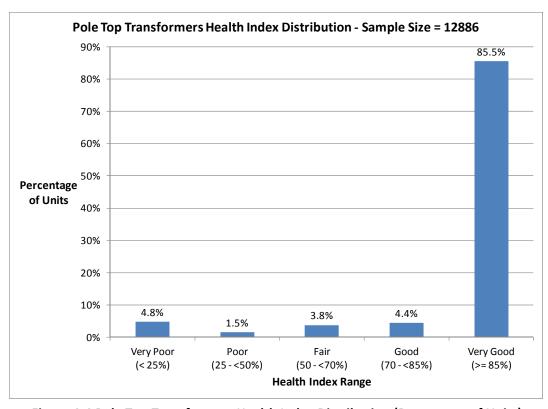


Figure 4-4 Pole Top Transformers Health Index Distribution (Percentage of Units)

# 4.5 Pole Top Transformers Condition-Based Flagged-For-Action Plan

As it is assumed that Pole Top Transformers are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

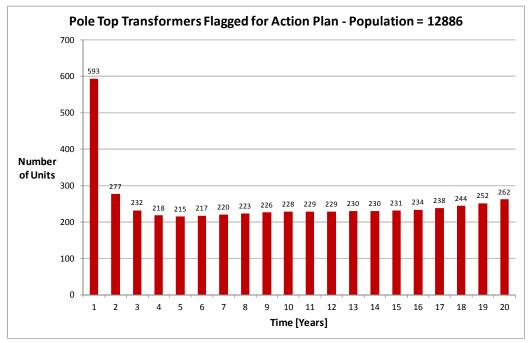


Figure 4-5 Pole Top Transformers Condition-Based Flagged-For-Action Plan

# 4.6 Pole Top Transformers Data Analysis

The data available for Pole Top Transformers includes age and loading determined using hourly data obtained from Horizon Utilities Smart Meter data.

#### 5 Overhead Conductors

Electrical current flows through distribution line conductors facilitating the movement of power throughout the distribution system. These conductors are supported by either metal, wood or concrete structures to which they are attached by insulator strings selected based on operating voltage. The conductors are sized for the maximum amount of current to be carried and other design requirements. In this study, there are three types of overhead conductor system:

- Primary overhead conductors
- Secondary overhead conductors
- Service overhead conductors

#### 5.1 Overhead Conductors Degradation Mechanism

Conductors used on most distribution lines have high tensile strength, enabling them to be strung over long spans. As electrical current passes through a conductor, its temperature rises. The temperature change is proportional to the square of the current passing through the conductor. The rise in temperature causes the conductor to expand and sag more between points of support, reducing the height of the conductor above ground. This may reduce the line's clearance from ground by 10 feet or more, depending on the conductor's span length, temperature increase, ambient temperature, and wind and solar conditions. The minimum allowable clearance (thermal rating), as per Canadian Standards Association (CSA) C22.3 No. 1-Overhead Systems, limits the amount of loading of a line.

To work properly, conductors must retain both their conductive properties and their mechanical (i.e., tensile) strength. Aluminum-based conductors have three primary modes of degradation -corrosion, fatigue and creep. The rate of each degradation mode depends on several factors, including the size and construction of the conductor, the amount of steel in the cross-section, and the environmental and operating conditions. Most utilities find that corrosion and fatigue present the most critical forms of degradation to their conductors.

Generally, corrosion represents the most critical life-limiting factor for conductors. Visual inspection cannot detect corrosion readily in conductors. Environmental conditions affect degradation rates from corrosion. Both aluminum and zinc-coated steel core conductors are particularly susceptible to corrosion from chlorine-based pollutants, even in low concentrations. ACSR used in extreme marine environments may have a useful life of only 30 years, even with the use of anti-corrosion measures (e.g., greasing). Under minor marine-type pollution, aluminum-based conductors still may have a relatively short life of about 50 years.

Fatigue degradation presents an even greater detection and assessment challenge than corrosion degradation. In extreme circumstances, under high tensions or inappropriate vibration or galloping control, fatigue can occur in very short timeframes (i.e., less than 20 years). However, under normal operating conditions, with proper design and application of vibration control devices such as dampers, fatigue degradation rates are relatively slow. Under normal circumstances, widespread fatigue degradation is not commonly seen in conductors less

than 70 years of age. Also, in many cases, detectable indications of fatigue may only exist during the last 10% of a conductor's life.

The tensile strength of conductors gradually decreases over time. When aluminum-based conductors experience unexpectedly large mechanical loads (for example, when heavily ice-coated) and experience tensions beyond 50% of their RTS, they can begin to undergo permanent stretching with noticeable increases in sagging. After conductor stretching has occurred, one can estimate damage severity by measuring sag in the affected spans and then comparing the measured sag to that predicted based on the "as constructed" sag charts.

Overloading lines beyond their thermal capacity causes elevated operating temperatures. When operating at elevated temperatures, aluminum conductors begin to anneal and lose tensile strength. Each elevated temperature event adds further damage to the conductor. Because of their steel cores, ACSR can withstand substantially greater annealing degradation than all-aluminum (e.g. ACAR) conductors.

Phase to phase power arcs can result from conductor galloping during severe ice and wind storm events. This can cause localized burning and melting of a conductor's aluminum strands, reducing strength at those sites and potentially leading to conductor failures if not repaired. Visual inspection from a helicopter readily detects severe arcing damage.

Forms of conductor damage include:

- Broken strands due to fatigue cracking (i.e. outer and/or inner strands)
- Vandalism (gunshot) damage
- Strand abrasion at or near clamping points
- Elongation (i.e. changes in sags and tensions)
- Burn damage (i.e. lightning strikes or power arcs/wire clashing)
- Birdcaging (ballooning) of the outer, aluminum strands

#### 5.2 Overhead Conductors Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Overhead Conductors. The Health Index equation is shown Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

#### 5.2.1 Overhead Conductors Condition and Sub-Condition Parameters

Table 5-1 Overhead Conductors Condition Weights and Maximum CPS

| m | Condition Parameter | WCP <sub>m</sub> | CPS Lookup Table |  |
|---|---------------------|------------------|------------------|--|
| 1 | Service Record      | 1                | Table 5-2        |  |
|   | De-rating m         | ultiplier (DR)   | Table 5-3        |  |

Table 5-2 Overhead Conductors Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Age                        | Figure 5-1       | 1                 | 4                    |

#### 5.2.2 Overhead Conductors Condition Parameter Criteria

#### Age

Assume that the failure rate for Overhead Conductors exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure Assuming that for primary/secondary/service overhead conductors, at the ages of 60 and 77 years the probability of failure ( $P_f$ ) for this asset are 20% and 95% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

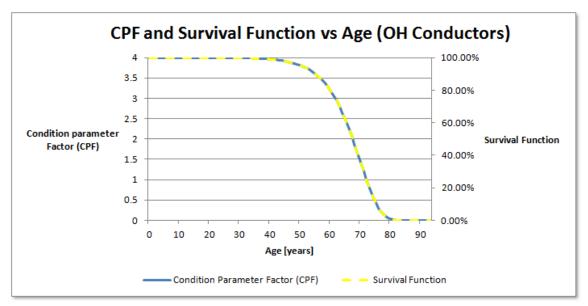


Figure 5-1 Overhead Conductors Age Condition Criteria

## **De-Rating (DR) Multiplier**

**Table 5-3 Overhead Conductors De-Rating Factors** 

| De-Rating Factor | Description                               |
|------------------|---|
| 0.3              | #6 copper conductor for primary conductor |

# 5.3 Overhead Conductors Age Distribution

The age distribution is shown in the figures below. Age was available for 100% of the population. The average age was found to be 28, 38 and 40, for primary, secondary and service overhead conductors respectively.

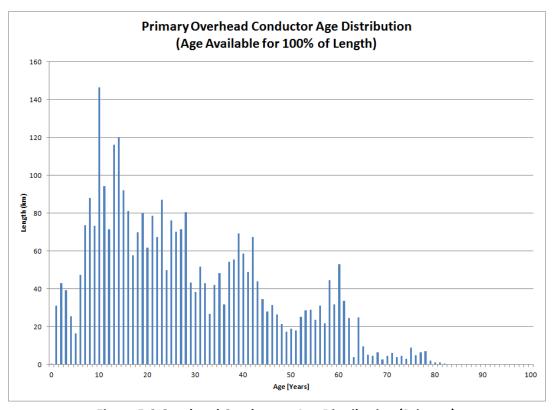


Figure 5-2 Overhead Conductors Age Distribution (Primary)

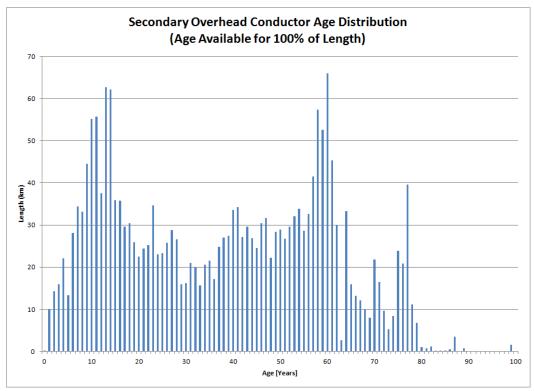


Figure 5-3 Overhead Conductors Age Distribution (Secondary)

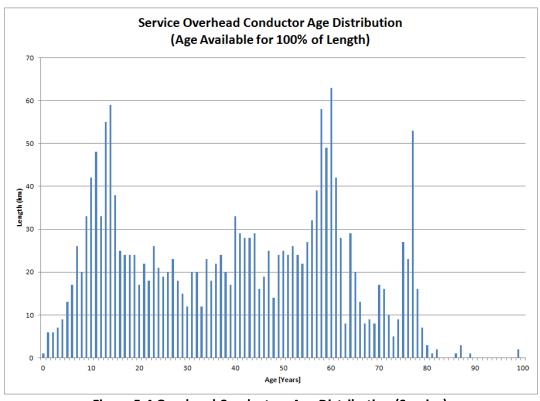


Figure 5-4 Overhead Conductors Age Distribution (Service)

### 5.4 Overhead Conductors Health Index Results

There are 3385 km, 2196 km and 1897 km in-service Overhead Conductors at Horizon Utilities, for primary, secondary and service systems respectively. The condition assessment is mainly age-driven, together with de-rating based on #6 copper conductor type for primary conductors only.

The average Health Index for this asset group is 90%, 86% and 84% for primary, secondary and service systems respectively.

The Health Index Results are as follows:

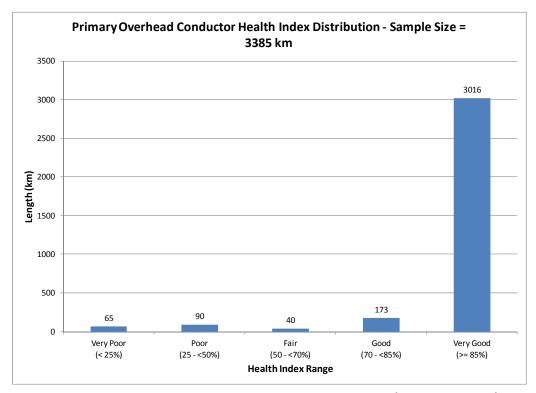


Figure 5-5 Overhead Conductors Health Index Distribution (Length, Primary)

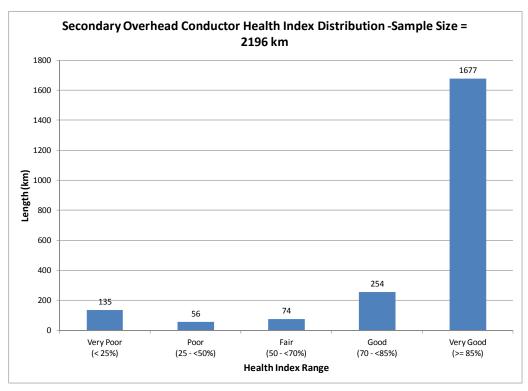


Figure 5-6 Overhead Conductors Health Index Distribution (Length, Secondary)

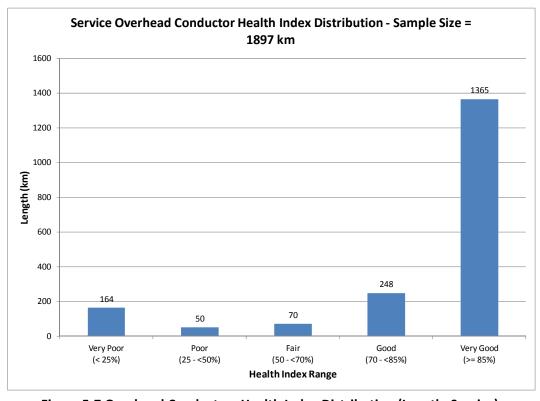


Figure 5-7 Overhead Conductors Health Index Distribution (Length, Service)

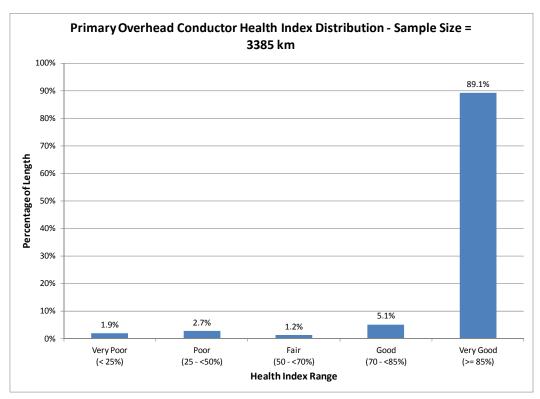


Figure 5-8 Overhead Conductors Health Index Distribution (Percentage, Primary)

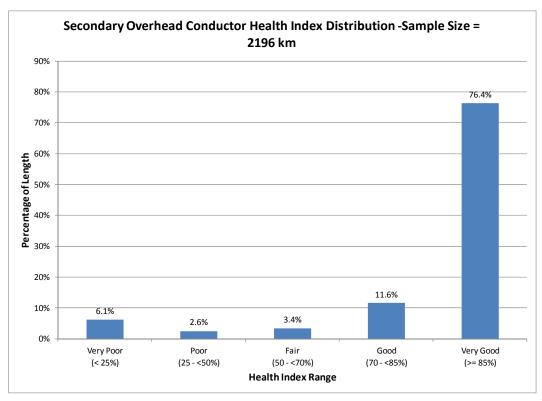


Figure 5-9 Overhead Conductors Health Index Distribution (Percentage, Secondary)

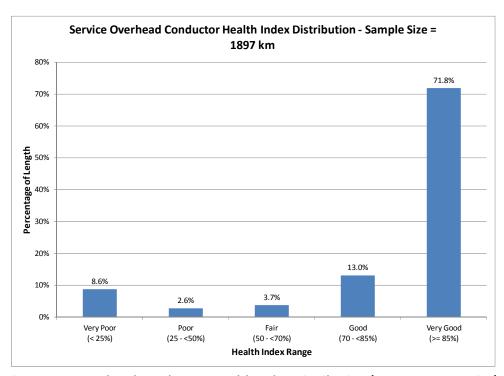


Figure 5-10 Overhead Conductors Health Index Distribution (Percentage, Service)

The following diagrams show the primary Overhead Conductors Health Index distribution by different voltage levels.

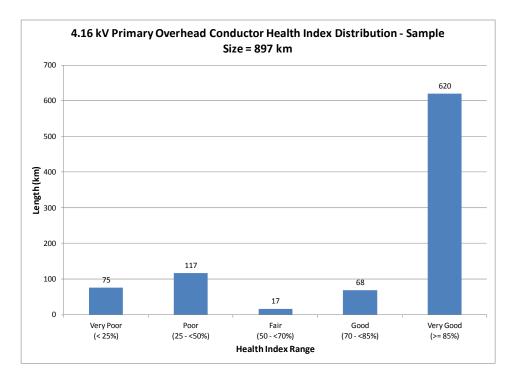


Figure 5-11 Overhead Conductors Health Index - Primary 4.16 kV

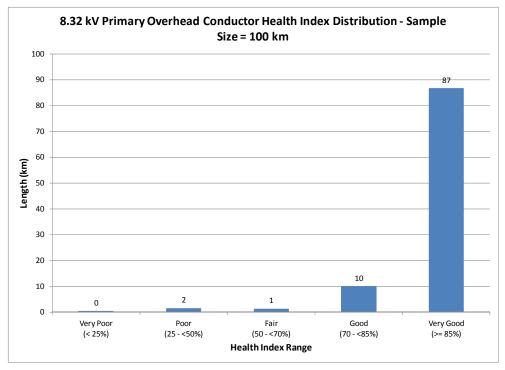


Figure 5-12 Overhead Conductors Health Index – Primary 8.32 kV

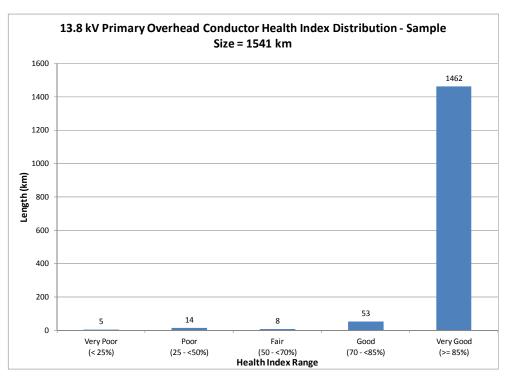


Figure 5-13 Overhead Conductors Health Index - Primary 13.8 kV

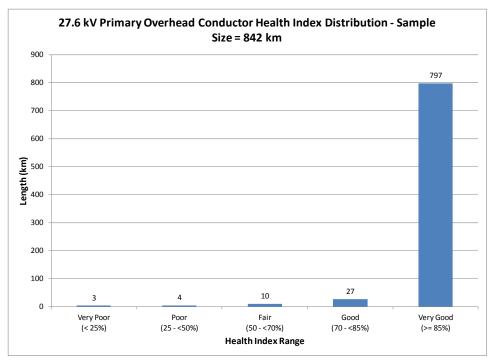


Figure 5-14 Overhead Conductors Health Index - Primary 27.6 kV

# 5.5 Overhead Conductors Condition-Based Flagged-For-Action Plan

As it is assumed that Overhead Conductors are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The optimal Flagged-For-Action Plan is based on the number of expected failures in a given year.

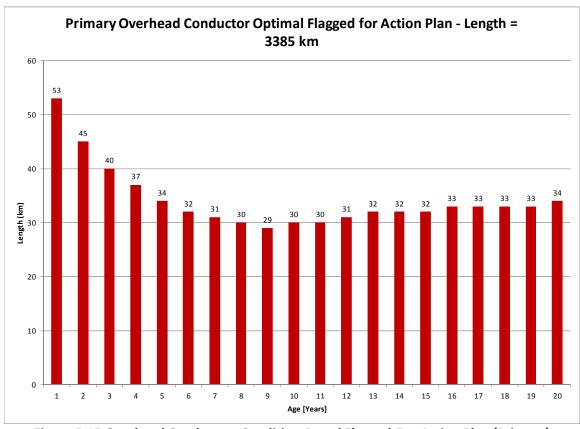


Figure 5-15 Overhead Conductors Condition-Based Flagged-For-Action Plan (Primary)

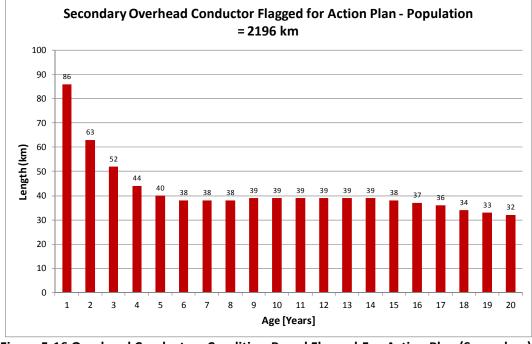


Figure 5-16 Overhead Conductors Condition-Based Flagged-For-Action Plan (Secondary)

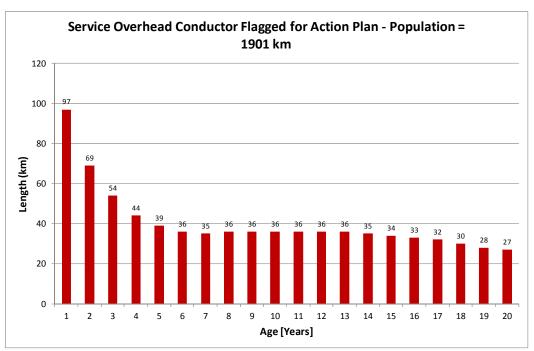


Figure 5-17 Overhead Conductors Condition-Based Flagged-For-Action Plan (Service)

# 5.6 Overhead Conductors Data Analysis

The data available for Overhead Conductors includes age and material. Horizon Utilities should continue with the existing practices. It is also recommended that some of the removed primary conductors or primary conductors at some critical locations suspected to be at the end of their lives be tested.

## 6 Overhead Line Switches

The primary function of switches is to allow isolation of line sections or equipment for maintenance, safety or other operating requirements. Disconnect switches are relatively simple in design compared to circuit breakers, since they are not typically required to interrupt fault current.

In general, line switches consist of mechanically movable copper blades supported on insulators and mounted on metal bases. Their operating mechanism can be either a simple hook stick or a manually driven mechanical mechanism to move the ganged contacts. Air serves as the insulating medium between contacts when these switches are in the open position. Air break switches must have the capability of providing visual confirmation of the open/close position. Disconnect switches are sometimes provided with padlocks to allow staff to obtain work permit clearance with switch handle locked in open position.

Most distribution line switches are rated 600 A continuous rating. While some categories of the switches are rated for load interruption, others are designed to operate under no load conditions. Non-load break switches operate only when the current through the switch is zero. When used in conjunction with cutout fuses, switches provide short circuit interruption rating.

## 6.1 Overhead Line Switches Degradation Mechanism

The main degradation processes associated with line switches include:

- Corrosion of steel hardware or operating rod
- Mechanical deterioration of linkages
- Switch blades falling out of alignment, which may result in excessive arcing during operation
- Loose connections
- Nonfunctioning padlocks
- Insulators damage
- Missing ground connections

The rate and severity of these degradation processes depends on a number of inter-related factors including the operating duties and environment in which the equipment is installed. In most cases, corrosion or rust represents a critical degradation process.

Corrosion typically occurs around the mechanical linkages of these switches. Corrosion can cause seizing. When lubrication dries out the switch operating mechanism may seize making the disconnect switch inoperable. While a lesser mode of degradation, air pollution also can affect support insulators. Typically, this occurs in heavy industrial areas or where road salt is used.

The condition assessment of overhead switches involves visual inspections which would reveal the extent of wear or corrosion on main contacts, condition of stand-off insulators and operating mechanism. Thermographic surveys using infrared cameras represent one of the easiest and most cost-effective tests to locate hot spots.

Consequences of overhead line switch failure may include customer interruption and health and safety consequences for operators.

#### 6.2 Overhead Line Switches Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Overhead Line Switches. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

#### 6.2.1 Overhead Line Switches Condition and Sub-Condition Parameters

Table 6-1 Condition Weights and Maximum CPS

| m | Condition Parameter | WCP <sub>m</sub> | CPS Lookup Table |
|---|---------------------|------------------|------------------|
| 1 | Service Record      | 1                | Table 6-2        |

Table 6-2 Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Age                     | Figure 6-1          | 1                 | 4                    |

#### 6.2.2 Condition Parameter Criteria

#### Age

Assume that the failure rate for Overhead Line Switches exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function

 $P_f$  = probability of failure

Assuming that at the ages of 40 and 50 years the probability of failure ( $P_f$ ) for this asset are 50% and 80% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

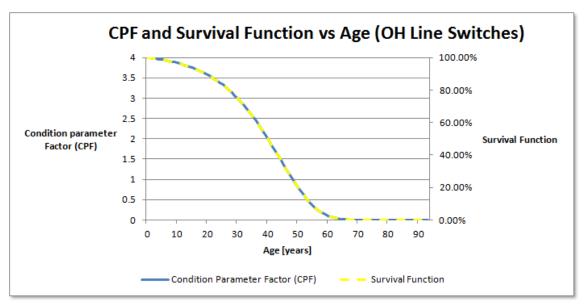


Figure 6-1 Overhead Line Switches Age Condition Criteria (Overhead Line Switches)

# 6.3 Overhead Line Switches Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 26 years.

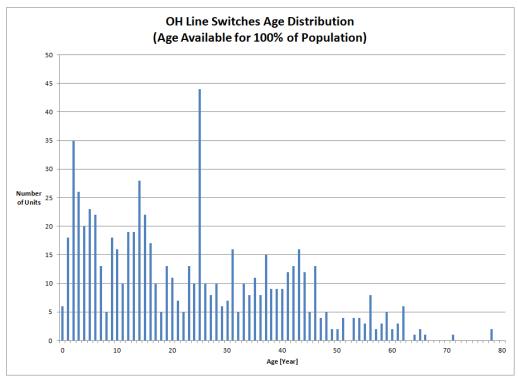


Figure 6-2 Overhead Line Switches Age Distribution

## 6.4 Overhead Line Switches Health Index Results

There are 712 in-service Overhead Line Switches at Horizon Utilities. The condition assessment is age-driven.

The average Health Index for this asset group is 76%. Approximately 20% of the units were found to be in poor or very poor condition.

The Health Index Results are as follows:

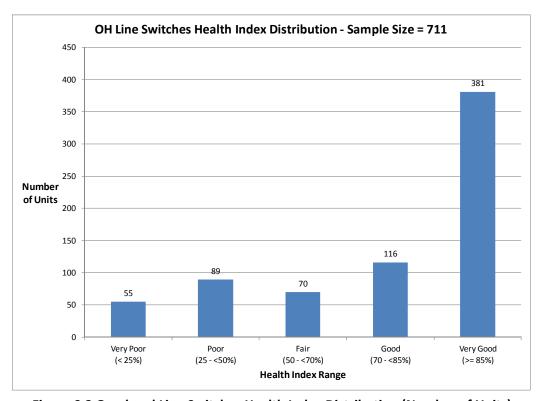


Figure 6-3 Overhead Line Switches Health Index Distribution (Number of Units)

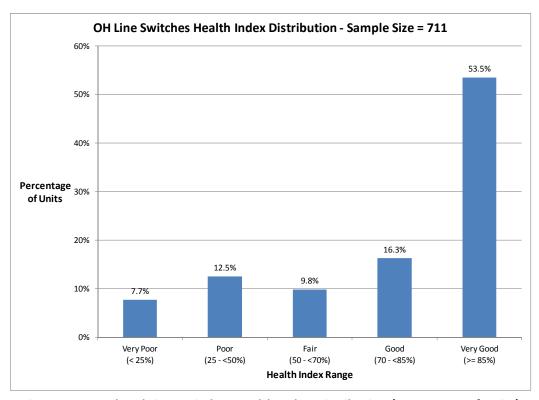


Figure 6-4 Overhead Line Switches Health Index Distribution (Percentage of Units)

# 6.5 Overhead Line Switches Condition-Based Flagged-For-Action Plan

As it is assumed that Overhead Line Switches are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

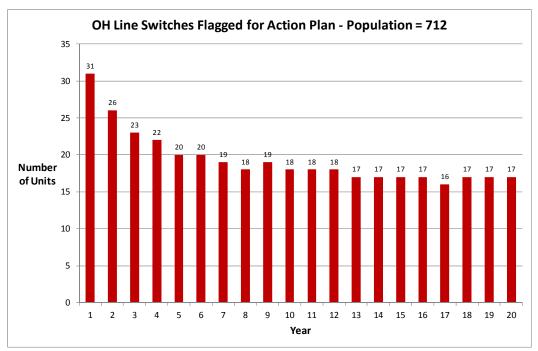


Figure 6-5 Overhead Line Switches Condition-Based Flagged-For-Action Plan

# 6.6 Overhead Line Switches Data Analysis

The data available for Overhead Line Switches includes age only.

VI - Appendix A: Results and Findings for Each Asset Category

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## 7 Wood Poles

Wood poles are used to support primary distribution lines at voltages from 4.16 kV to 44 kV. The wood species commonly used for distribution wood poles predominantly include Red Pine, Jack Pine and Western Red Cedar (WRC), either butt-treated or full-length treated. Smaller numbers of Larch, Fir, White Pine and Southern Yellow Pine have also been used.

Distribution line design standards dictate usage of poles of varying height and strength, depending upon the number and size of conductors, the average length of adjacent spans, maximum loadings, line angles, appropriate loading factors and the mass of installed equipment. Poles are categorized into Classes (1 to 7) which reflect the relative strength of the pole. Stronger poles (lower numbered classes) are used for supporting equipment and handling stresses associated with corner structures and directional changes in the line. The height of a pole is determined by a number of factors, such as the number of conductors it must support, equipment-mounting requirements, clearances below the conductors for roads and the presence of coaxial cable and/or other telecommunications facilities.

## 7.1 Wood Poles Degradation Mechanism

Since wood is a natural material, the degradation processes are somewhat different to those which affect other physical assets on electricity distribution systems. The critical processes are biological involving naturally occurring fungi that attack and degrade wood, resulting in decay. The nature and severity of the degradation depends both on the type of wood and the environment. Certain species of fungi are known to attack the external surfaces of the pole and some the internal heartwood. Therefore, the mode of degradation can be split into either external rot or internal rot. As the decay processes requires the presence of water and oxygen, the area of the pole most susceptible to degradation is at and around the ground line or at the top of the pole. Although it is possible in some circumstances for decay to occur in other locations, it is normal to concentrate inspection and assessment of poles in the most critical areas. In addition to the natural degradation processes, external damage to the pole by wildlife can also be a significant problem. Examples may include attack by termites, small mammals or woodpeckers.

To prevent attack and decay, wood poles are treated with preservatives prior to being installed. The preservatives have two functions; firstly, to keep out moisture vital to fungal attacks, and, secondly, as a biocide to kill off fungus spores. As wood pole use has evolved in the electricity industry, the nature of the preservatives used to treat the wood has also evolved, as the chemicals used previously have become unacceptable from an environmental viewpoint.

As a structural item, the sole concern when assessing the condition of a wood pole is the native reduction in mechanical strength due to degradation or damage. A particular problem when assessing wood poles is the potentially large variation in their original mechanical properties. Depending on the species, the mechanical strength of a new wood pole can vary greatly. Typically, the first standard deviation has a width of  $\pm 15\%$  for poles nominally in the same class.

However, in some test programs, the minimum measured strength has been as low as 50% of the average.

Assessment techniques start with simple visual inspection of poles. This is often accompanied by basic physical tests such as prodding tests and hammer tests to detect evidence of internal decay. Over the past 20 years, electricity companies have sought more objective and accurate means of determining condition and estimating remaining life. This has led to the development of a wide range of condition assessment and diagnostic tools and techniques for wood poles. These include techniques that are designed to apply the traditional probing or hammer tests in a more controlled, repeatable and objective manner. Devices are available that measure the resistance of a pin fired into the pole to determine the severity of external rot and instrumented hammers that record and analyze the vibration caused by a hammer blow to identify patterns that indicate the presence of decay. Direct assessment of condition by using a decay resistance drill or an auger to extract a sample through the pole, are also widely used. Indirect techniques, ultrasonic, X-rays, electrical resistance measurement have also been widely used.

Although wood pole condition assessment is driven by the condition of the wood pole itself, replacement of the ancillary components, foundations, cross-arms, guys, anchors and insulators may also be required. The poles, foundations and cross-arms support the required insulators and phase conductors. The guys and anchors maintain the mechanical integrity of the structure and the insulators electrically insulate the conductors from ground potential.

There are many factors considered by utilities when establishing condition for wood poles. These include species of wood, historic rates of decay and average lifetimes, environment, perceived effectiveness of available techniques and cost. However, perhaps the most significant is the policy of routine line inspections. A foot patrol of overhead lines undertaken on a regular cycle is extremely effective in addressing the required safety and security obligations.

Consequences of an in-service pole failure are quite serious, as they could lead to a serious accident involving the public. Depending on the number of circuits supported, a pole failure may also lead to a power interruption for a significant number of customers.

#### 7.2 Wood Poles Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Wood Poles. The Health Index equation is shown in Section II.1; the condition, subcondition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

## 7.2.1 Wood Poles Condition and Sub-Condition Parameters

Table 7-1 Wood Poles Condition Weights and Maximum CPS

| m Condition Parameter |                | WCP <sub>m</sub> | CPS Lookup Table |
|-----------------------|----------------|------------------|------------------|
| 1                     | Pole Strength  | 5                | Table 7-2        |
| 2                     | Service Record | 3                | Table 7-3        |

Table 7-2 Wood Pole Strength (m=1) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|------------------|-------------------|----------------------|
| 1 | Pole Strength           | Table 7-5        | 1                 | 4                    |

Table 7-3 Wood Poles Service Record (m=4) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Age                        | Figure 7-1       | 2                 | 4                    |
| 2 | Overall                    | Table 7-4        | 1                 | 4                    |

### 7.2.2 Wood Poles Condition Parameter Criteria

# **Overall Condition**

**Table 7-4 Wood Poles Overall Condition Criteria** 

| CPF | Description |
|-----|-------------|
| 4   | Good        |
| 2   | Fair        |
| 0   | Poor        |

# **Pole Strength**

**Table 7-5 Pole Strength Condition Criteria** 

| CPF | Description (percentage of original strength at installation) |  |  |
|-----|---|--|--|
| 4   | 100   |  |  |
| 3   | 90  |  |  |
| 2   | 75  |  |  |
| 1   | 66  |  |  |
| 0   | 33  |  |  |

### Age

Assume that the failure rate for Wood Poles exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 50 and 65 years the probability of failures ( $P_f$ ) for this asset are 20% and 80% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age for wood poles is also shown in the figure below:

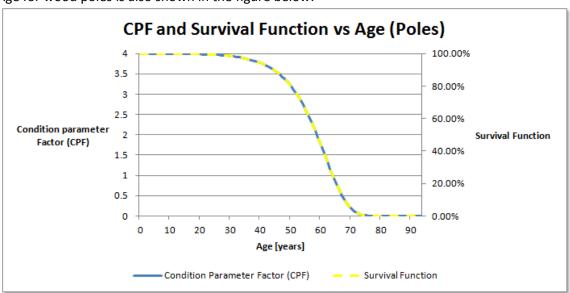


Figure 7-1 Wood Pole Age Condition Criteria (Wood Poles)

# 7.3 Wood Poles Age Distribution

The age distribution is shown in the figure below. Age was available for all the population. The average age was found to be 32 years.

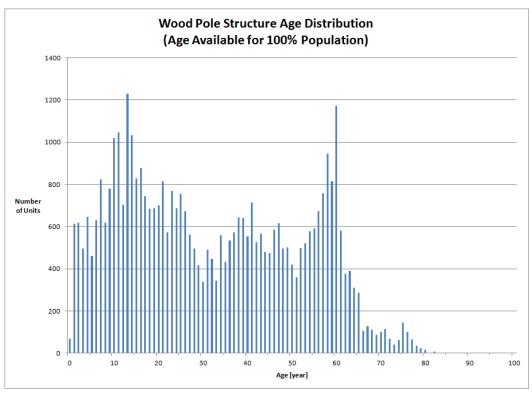


Figure 7-2 Wood Poles Age Distribution

## 7.4 Wood Poles Health Index Results

There are 42037 in-service Wood Poles at Horizon Utilities.

The average Health Index for this asset group is 86%. Approximately 11% of the units were found to be in poor or very poor condition.

The Health Index Results are as follows:

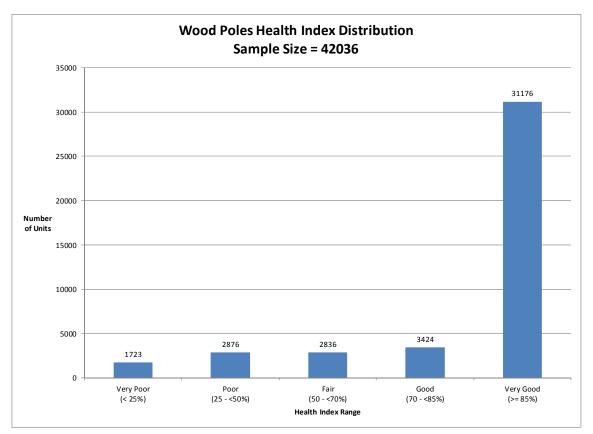


Figure 7-3 Wood Poles Health Index Distribution (Number of Units)

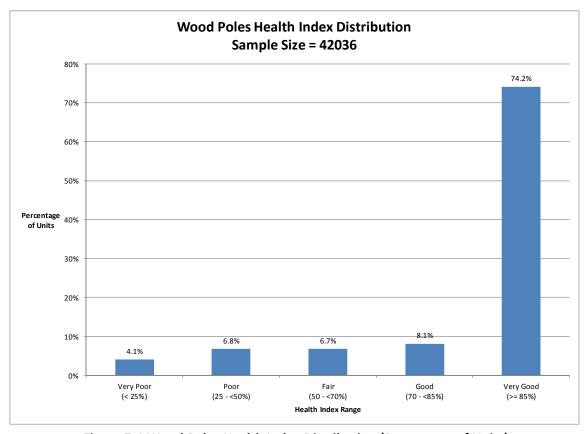


Figure 7-4 Wood Poles Health Index Distribution (Percentage of Units)

# 7.5 Wood Poles Condition-Based Flagged-For-Action Plan

As it is assumed that Wood Poles are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

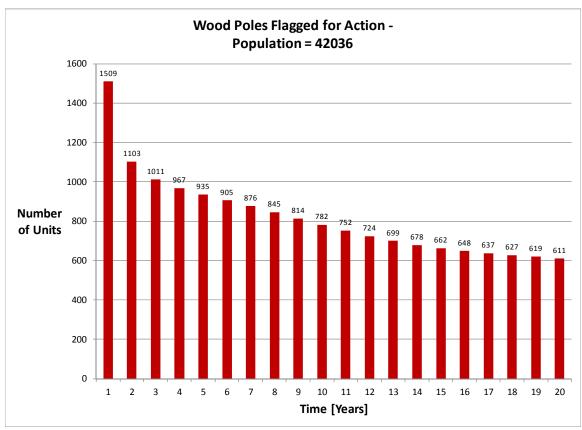


Figure 7-5 Wood Poles Condition-Based Flagged-For-Action Plan

# 7.6 Wood Poles Data Analysis

It is recommended that Horizon Utilities continues with the existing wood pole testing and inspection practices.

VI - Appendix A: Results and Findings for Each Asset Category

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### 8 Concrete Poles

Concrete poles are used primarily in the construction of higher voltage distribution or subtransmission overhead lines. They are available with round, square and octagonal cross-sections in lengths up to 60 feet. The strength of the pole is specified by a Class from A to D indicating light to heavy duty. They are supplied with a variety of pre-determined attachment patterns. Concrete poles are a relatively expensive option compared to wood or steel poles. They are heavy to transport and install. They have a clean matte appearance that is stable over long time periods and blends in to most environments. They have a longer expected service life than wood or steel. They are harder to climb and to make attachments to once they are in service.

### 8.1 Concrete Poles Degradation Mechanism

Concrete poles age in the same manner as any other concrete structure. Any moisture ingress inside the concrete pores would result in freezing during the winter and damage to concrete surface. Road salt spray can further accelerate the degradation process and lead to concrete spalling. Typical concrete mixes employ a washed-gravel aggregate and have extremely high resistance to downward compressive stresses (about 3,000 lb./sq. in); however, any appreciable stretching or bending (tension) will break the microscopic rigid lattice resulting in cracking and separation of the concrete. The spun concrete process used in manufacture of poles prevents moisture entrapment inside the pores. Spun, pre-stressed concrete is particularly resistant to corrosion problems common in a water-and-soil environment.

#### 8.2 Concrete Poles Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Concrete Poles. The Health Index equation is shown in Section II.1; the condition, subcondition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 8.2.1 Concrete Poles Condition and Sub-Condition Parameters

Table 8-1 Concrete Poles Condition Weights and Maximum CPS

| m Condition Parameter |                | WCP <sub>m</sub> | CPS Lookup Table |
|-----------------------|----------------|------------------|------------------|
| 1                     | Service Record | 1                | Table 7-3        |

Table 8-2 Concrete Poles Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Age                        | Table 8-1        | 1                 | 4                    |

#### 8.2.2 Concrete Poles Condition Parameter Criteria

#### Age

Assume that the failure rate for Concrete Poles exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

= failure rate of an asset (percent of failure per unit time)

= constant parameters that control the rise of the curve α, β

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 65 and 80 years the probability of failures (Pf) for this asset are 50% and 85% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age for concrete poles is also shown in the figure below:

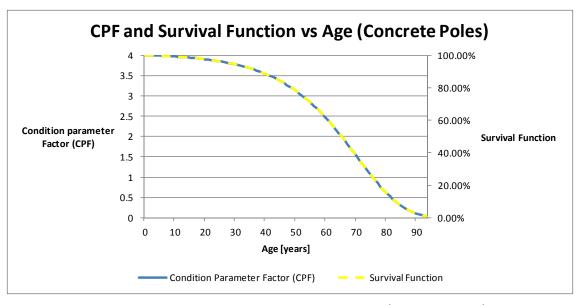


Figure 8-1 Concrete Pole Age Condition Criteria (Concrete Poles)

# 8.3 Concrete Poles Age Distribution

The age distribution is shown in the figure below. Age was available for all the population. The average age was found to be 27 years.

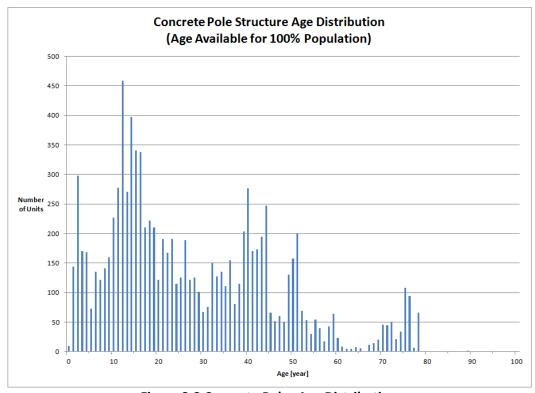


Figure 8-2 Concrete Poles Age Distribution

### 8.4 Concrete Poles Health Index Results

There are 9761 in-service Concrete Poles at Horizon Utilities. The HI is based on age only.

The average Health Index for this asset group is 90%. Approximately 31% of the units were found to be in poor or very poor condition.

The Health Index Results are as follows:

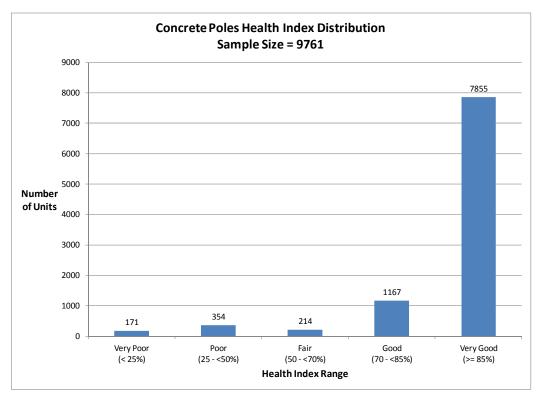


Figure 8-3 Concrete Poles Health Index Distribution (Number of Units)

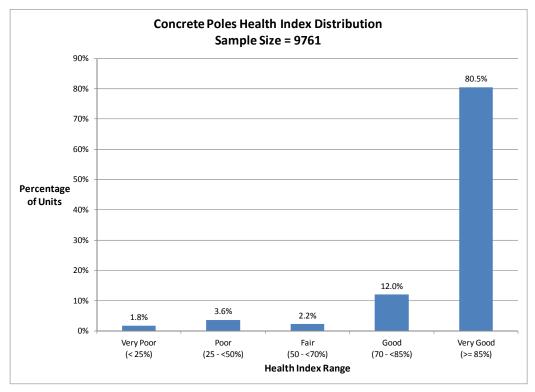


Figure 8-4 Concrete Poles Health Index Distribution (Percentage of Units)

# 8.5 Concrete Poles Condition-Based Flagged-For-Action Plan

As it is assumed that Concrete Poles are proactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

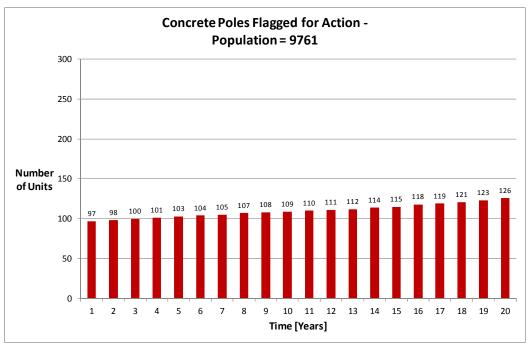


Figure 8-5 Concrete Poles Condition-Based Flagged-For-Action Plan

# 8.6 Concrete Poles Data Analysis

The data available for Concrete Poles includes age only.

# 9 Underground Cables

The asset category of distribution system underground cables includes underground cross-link-polyethylene (XLPE) cables, paper insulated lead covered (PILC) cables, splices/joints, elbows, potheads and terminators at voltage levels 44 kV and below. It includes direct buried and installed-in-duct feeder cables, underground cable sections running from stations to overhead lines and from overhead lines to customer stations and switches.

The use of insulated cables on distribution feeders has virtually become a standard in most North American jurisdictions for urban residential areas where it is either impossible or extremely difficult to build overhead lines due to aesthetic, legal, environmental or safety reasons. The initial capital cost of a distribution underground feeder cable circuit is approximately three times the cost of an overhead line of equivalent capacity and voltage.

Distribution underground feeder cables are one of the more challenging assets for electricity systems from a condition assessment and asset management viewpoint. Underground cables are a relatively expensive asset. However, it is very difficult and therefore very expensive to obtain meaningful condition information for buried cables. Underground cable systems, unlike overhead lines, do not suffer from weather induced faults and have better reliability records.

In this study, there are three types of underground cable system:

- Primary underground cable
- Secondary underground cable
- Service underground cable

#### 9.1 Underground Cables Degradation Mechanism

Faults on underground feeder cables are usually caused by insulation failure within a localized area and when failures do occur they can be repaired at much lower cost than replacement of the entire cable. Thus, the standard approach to cable system management has been based on reliability rather than the balance between repair and replacement costs. As long as the reliability is within acceptable levels, it is virtually always cheaper to repair than replace cables.

Many utilities with high proportions of over 40 years old underground cables have concerns about reliability. Condition assessment programs enable utilities to prioritize the cable replacement programs based on available budgets.

Over the past 30 years XLPE insulated cables, due to their lower costs and easier splicing have all but replaced paper-insulated cables in new installations. The existing population of XLPE cables is still relatively young in terms of normal cable lifetimes. Therefore, failures that have occurred can be classified as early life failures. In the early days of polymeric insulated cables, their reliability was questionable. Many of the problems were associated with joints and accessories or defects introduced during manufacturing. Over the past 30 years many of these problems

have been addressed, and modern XLPE cables and accessories are generally considered very reliable if manufactured and installed through competent workmanship.

Polymeric insulation is very sensitive to discharge activity, thus, cable, joints and accessories must be discharge free when installed. Water penetration into the insulation/conductor barrier, existence of impurities within the semiconducting layer and presence of high dielectric stress are the principal causes of insulation treeing and the most significant degradation processes for earlier generation of polymeric cables. The rate of water tree growth depends on the quality of the polymeric insulation and the manufacturing process. In addition to manufacturing improvements, development of tree retardant XLPE cables and designs with metal foil barriers and water migration controls have further reduced the rate of deterioration from treeing.

Examining recovered failed cable samples to detect and quantify treeing serves as an effective means to assess the general condition and estimate the future life of XLPE cables. Alternatively, accelerated electrical testing of recovered cables can also be used to determine condition.

Most utilities are beginning to determine the condition of their cables through lab testing and in-situ testing. In the absence of testing, the only other indicators of cable health are:

- Number of failures per unit length of installation
- Age of Cables

At this time, the precise life expectancy of XLPE cables is difficult to ascertain. XLPE cable life expectancy is less than PILC cable. The life expectancy of early generation XLPE cables is expected to be less than 40 years while the newer, tree-retardant (TR) XLPE cables is expected to be in service in excess of 40 years.

The major consequences of cable failure are adverse impacts on reliability. Fundamentally, end of life cannot be predicted since most insulation system failures are related to the occurrence of a transient event such as an overvoltage caused by breaker operations, lightning strikes or flashovers, etc. However, diagnostic testing can indicate the status of insulation and therefore show the likelihood of failure at external factors.

#### 9.2 Underground Cables Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Underground Cables. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 9.2.1 Underground Cables Condition and Sub-Condition Parameters

Table 9-1 Condition Weights and Maximum CPS

| m | Condition Parameter       | WCP <sub>m</sub> | CPS Lookup Table |
|---|---------------------------|------------------|------------------|
| 1 | Service Record            | 1                | Table 9-2        |
|   | De-rating multiplier (DR) |                  | Table 9-3        |

Table 9-2 Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup table         | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|--------------------------|-------------------|----------------------|
| 1 | Age                        | Figure 9-1 to Figure 9-3 | 1                 | 4                    |

#### 9.2.2 Condition Criteria

#### Age

Assume that the failure rate for Underground Cables exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

#### --- Primary XLPE and Unknown

Assuming that at the ages of 30 and 40 years the probability of failures ( $P_f$ ) for this asset are 50% and 80% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

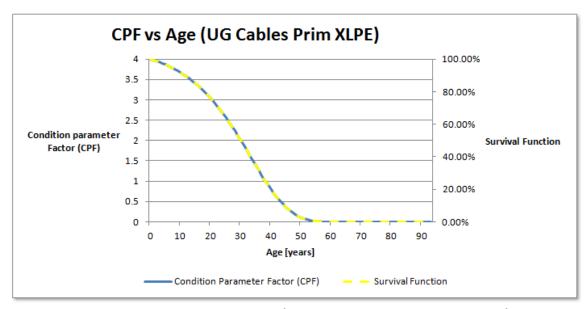


Figure 9-1 Age Condition Criteria (Underground Cables – Primary XLPE)

#### --- Primary PILC

Assuming that at the ages of 60 and 70 years the probability of failures ( $P_f$ ) for this asset are 25% and 50% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

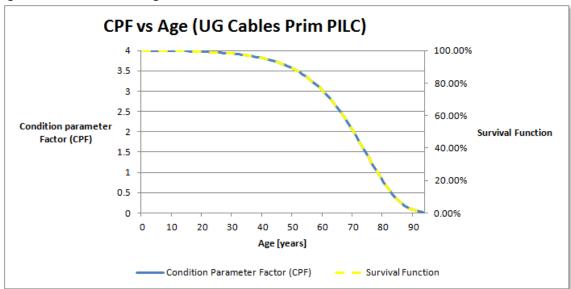


Figure 9-2 Age Condition Criteria (Underground Cables – Primary PILC)

#### --- Secondary/Service In-Duct and Direct Buried

Assuming that at the ages of 40 and 60 years the probability of failures ( $P_f$ ) for this asset are 60% and 90% respectively results in the survival curve shown below. It follows that the CPF for Age is

the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

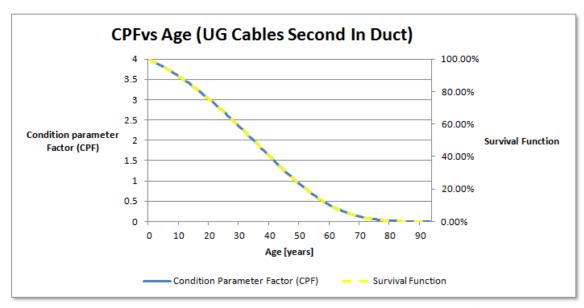


Figure 9-3 Age Condition Criteria (Underground Cables – Secondary/Service)

# **De-Rating (DR) Multiplier**

The de-rating is based on the following equation:

$$DR = \min(DRF_1, DRF_2, DRF_3)$$

Equation 9-1

Where DRF are as described in Table 9-3

**Table 9-3 De-Rating Factors** 

| De-<br>Rating<br>Factor<br>(DRF) | De-Rating Factor | Description  |
|----------------------------------|------------------|--|
| DRF <sub>1</sub>                 | 0.7              | Aluminum secondary and service cables older than year 1985 |
| DRF <sub>2</sub>                 | 0.7              | Stoney Creek Mountain primary cables (direct buried)       |

### 9.3 Underground Cables Age Distribution

The age distribution is shown in the figures below. Age was available for 100% of the population. The average age was found to be 22 and 34 years, for primary underground XLPE and PILC cables respectively. For both secondary underground direct buried and in-duct cables, the average age was found to be 29 years. For service underground direct buried and in-duct cables, the average age was found to be 33 and 13 years respectively.

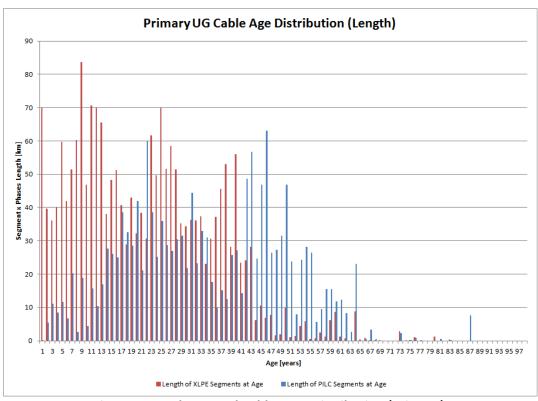


Figure 9-4 Underground Cables Age Distribution (Primary)

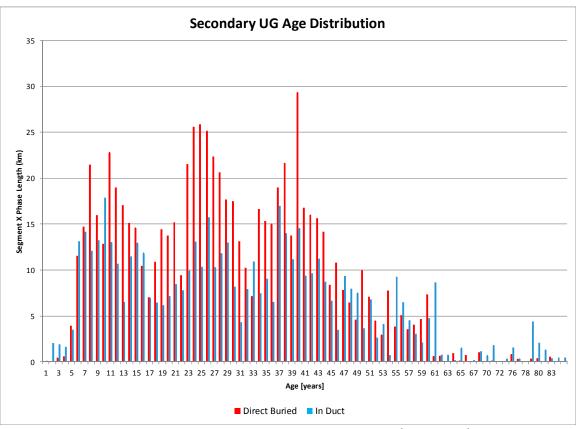


Figure 9-5 Underground Cables Age Distribution (Secondary)

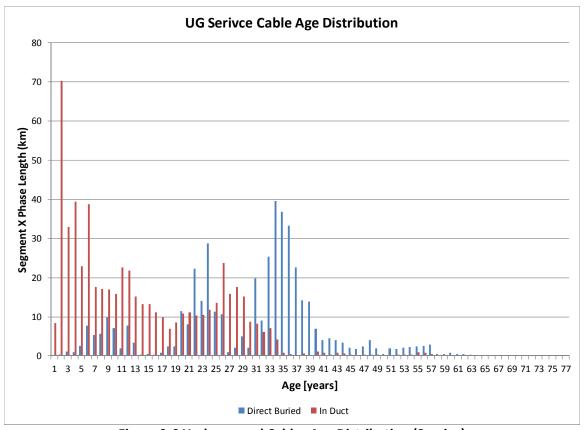


Figure 9-6 Underground Cables Age Distribution (Service)

# 9.4 Underground Cables Health Index Results

There are 3592 km, 1290 km and 1035 km in-service Underground Cables at Horizon Utilities, for primary, secondary and service systems respectively. The condition assessment is mainly age-driven, together with some de-ratings based on locations and conductor types.

The Health Index Results are as follows:

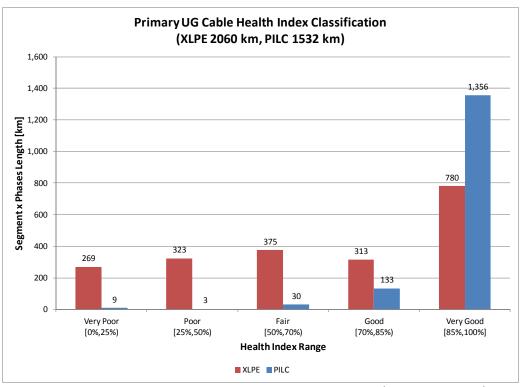


Figure 9-7 Underground Cables Health Index Distribution (Length, Primary)

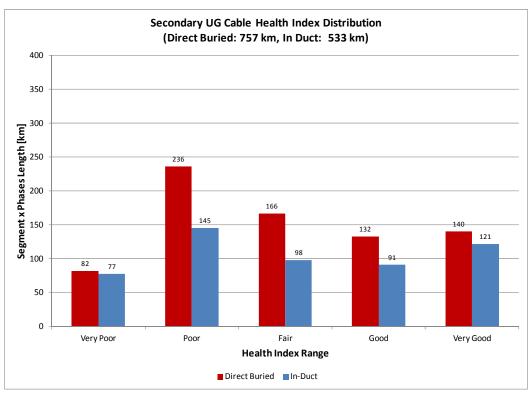


Figure 9-8 Underground Cables Health Index Distribution (Length, Secondary)

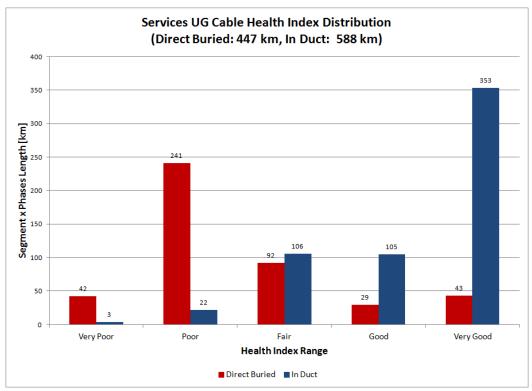


Figure 9-9 Underground Cables Health Index Distribution (Length, Service)

The following diagrams show the primary UG cables health index at different voltage level.

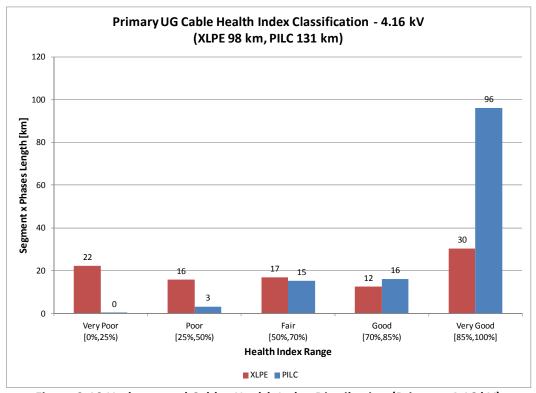


Figure 9-10 Underground Cables Health Index Distribution (Primary, 4.16 kV)

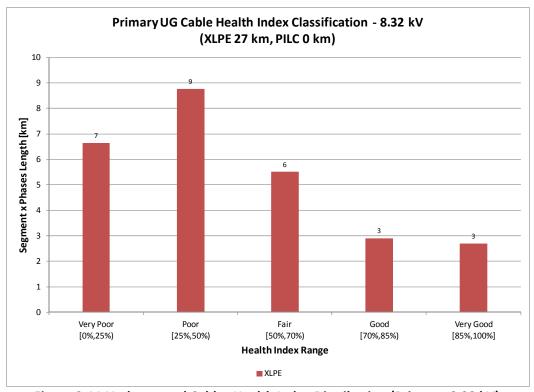


Figure 9-11 Underground Cables Health Index Distribution (Primary, 8.32 kV)

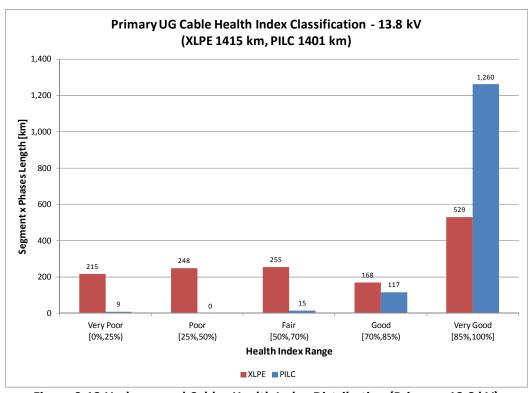


Figure 9-12 Underground Cables Health Index Distribution (Primary, 13.8 kV)

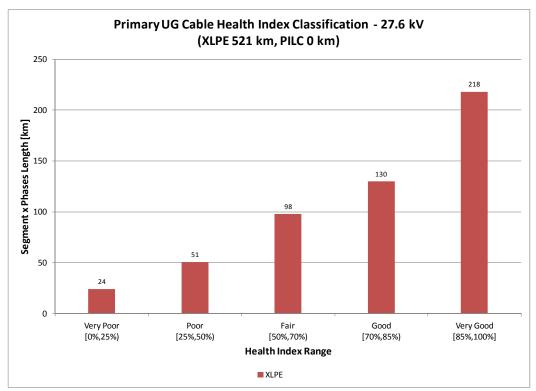


Figure 9-13 Underground Cables Health Index Distribution (Primary, 27.6 kV)

The following diagrams show the percentage health index distribution.

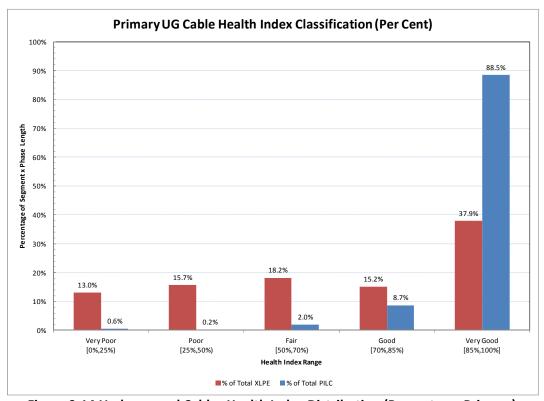


Figure 9-14 Underground Cables Health Index Distribution (Percentage, Primary)

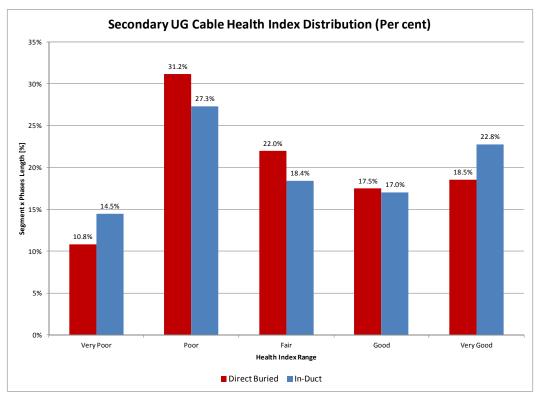


Figure 9-15 Underground Cables Health Index Distribution (Percentage, Secondary)

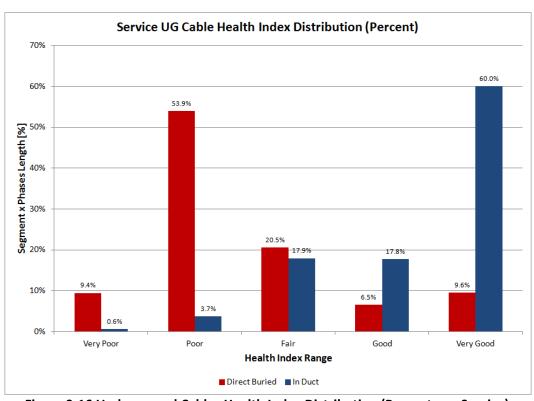


Figure 9-16 Underground Cables Health Index Distribution (Percentage, Service)

## 9.5 Underground Cables Condition-Based Flagged-For-Action Plan

As it is assumed that primary Underground Cables are proactively replaced while secondary and service cable is primary replaced reactively. The Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The optimal Flagged-For-Action Plan is based on the number of expected failures in a given year.

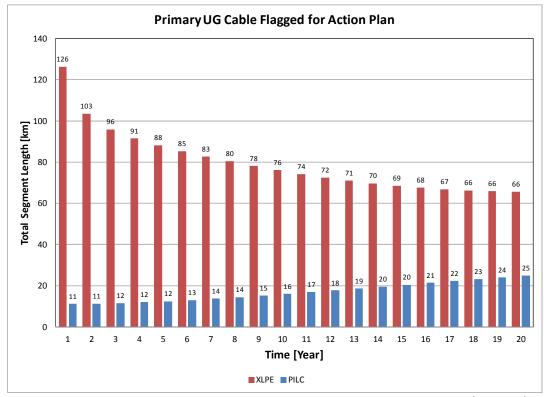


Figure 9-17 Underground Cables Condition-Based Flagged-For-Action Plan (Primary)

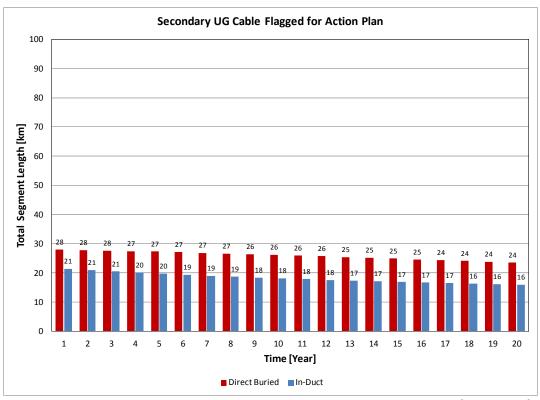


Figure 9-18 Underground Cables Condition-Based Flagged-For-Action Plan (Secondary)

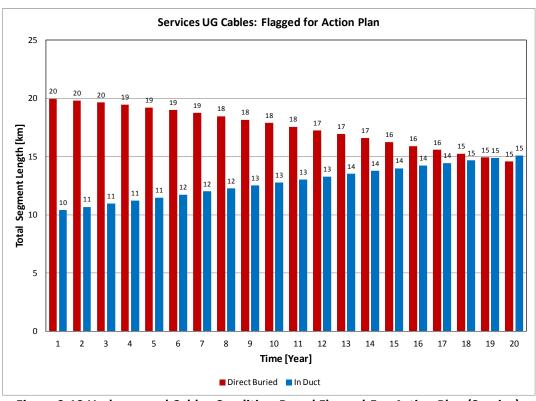


Figure 9-19 Underground Cables Condition-Based Flagged-For-Action Plan (Service)

# 9.6 Underground Cables Data Analysis

The data available for Underground Cables includes age, cable material and cable location.

VI - Appendix A: Results and Findings for Each Asset Category

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#### 10 Pad-Mounted Transformers

Pad-mounted transformers are used in underground distribution systems to step voltages down from primary system voltages (34.5kV to 4.2kV) to utilization voltages such as 120/240V and 600/347V.

Pad-mounted transformers are housed in low-profile metal enclosures which generally have an oil-filled compartment for the transformer windings and under-oil switches and protection as well as an air compartment under a hinged door for access to connections, switching and protection. The enclosure is placed on top of a concrete foundation which allows access for incoming cables. Foundations of 6'x6' by 3 feet deep are commonly utilized. Modern padmounted transformers are dead-front, with incoming and feed-through connections made using separable insulated connectors.

Fuses and switches are housed in the oil-filled compartment. Single-phase pad-mounted distribution transformers have ratings from 10 to 167kVA. Three-phase pad-mounted transformers are often used in industrial and commercial applications and are generally available in ratings from 45 to 2500kVA. Pad-mounted transformers are self-cooled and may have external cooling fins; however these are occasionally avoided because of potentially sharp external edges.

#### 10.1 Pad-Mounted Transformers Degradation Mechanism

Degradation of pad-mounted transformers can occur due to the following mechanisms:

- Corrosion of the pad-mounted enclosure and tank
- Deterioration of foundations
- Deterioration of separable insulated connectors
- Deterioration of switching or fusing devices
- Degradation of internal insulating material
- Degradation of oil

Pad-mounted transformers located in corrosive environments, such as next to major roads that are salted, are particularly prone to enclosure corrosion. Foundation shifting of pad-mounted transformers has been known to be problematic. Deep frost areas or unstable soil conditions can lead to movement of the foundation. Rubber encapsulated separable insulated connectors will deteriorate with multiple operations and are known to degrade if they are coated with transformer oil. Deterioration of the pad-mounted transformer can also be due to problems such as: switch breakage, leakage of under-oil fuses, and deterioration of dry-well canisters.

The life of the transformer's internal insulation is related to temperature-rise and duration. Therefore, transformer life is affected by electrical loading profiles and length of service life. The impacts of loading profiles, load growth, and ambient temperature on asset condition, loss-of-life, and life expectancy can be assessed using methods outlined in ANSI\IEEE Loading Guides. This also provides an initial baseline for the size of transformer that should be selected for a given number and type of customers to obtain optimal life.

Insulation condition can also be affected by voltage and current surges. Therefore, a combination of condition, age and load-based criteria is commonly used to determine the useful remaining life of distribution transformers.

Distribution transformers sometimes need to be replaced because of non-condition related factors such as mechanical damage by vehicles or customer load growth. If a transformer is simply overloaded, a decision is required whether to keep the transformer as spare or to scrap it. Many utilities make this decision through a cost benefit analysis, by taking into consideration anticipated remaining life of transformer, cost of equivalent sized new transformer, labour cost for transformer replacement and rated losses of the older transformer in comparison to the newer designs.

Visual inspections provide considerable information on transformer asset condition. Leaks, rusting, and deteriorated connectors can all be established by visual inspections. Transformer oil testing can be employed for distribution transformers to assess the condition of solid and liquid insulation.

The consequences of distribution transformer failure can be severe because of the street level location of this equipment. Though rare, pad-mounted transformers can fail with sufficient energy release to rupture the tank and release oil into the surrounding environment. Many utilities treat residential pad-mounted transformers as run-to-failure assets.

### 10.2 Pad-Mounted Transformers Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Pad-Mounted Transformers. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows:

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

Health Index condition and sub-condition parameters and condition criteria are as follows:

### 10.2.1 Pad-Mounted Transformers Condition and Sub-Condition Parameters

Table 10-1 Pad-Mounted Transformers Condition Weights and Maximum CPS

|   | Table 10 1 Table Medical Management Contaction Trends to Contact Maximum Co |                  |                  |  |  |
|---|---|------------------|------------------|--|--|
| m | <b>Condition Parameter</b>  | WCP <sub>m</sub> | CPS Lookup Table |  |  |
| 1 | Service Record  | 1                | Table 10-2       |  |  |

Table 10-2 Pad-Mounted Transformers Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Loading                    | Table 10-3       | 1                 | 4                    |
| 2 | Age                        | Figure 10-1      | 2                 | 4                    |

### 10.2.2 Pad-Mounted Transformers Condition Parameter Criteria

#### Age

Assume that the failure rate for Pad-Mounted Transformers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 40 and 55 years the probability of failure ( $P_f$ ) for this asset are 10% and 90% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

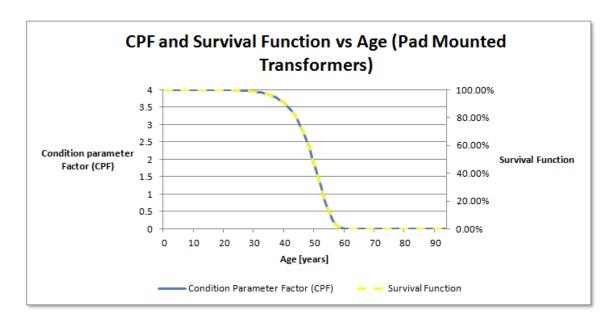


Figure 10-1 Age Condition Criteria (Pad-Mounted Transformers)

#### Loading

Table 10-3 Pad-Mounted Transformers Loading History

Data: S1, S2, S3, ..., SN recorded data (monthly 15 min peak)

SB= rated MVA

NA=Number of Si/SB which is lower than 1.0

NB= Number of Si/SB which is between 1 and 1.2

NC= Number of Si/SB which is greater than 1.2  $CPF = \frac{NA \times 4 + NB \times 1 + NC \times 0}{N}$ 

Hourly transformer loading was used to determine overloading occurrences leading to a loss of life and thereby increasing the effective age of the transformer. Transformer loading was not determined to decrease the effective age of the transformer in the absence of overloading occurrences. Therefore, loading condition was incorporated only when the loading CPF score was less than age CPF score for a transformer. In the cases when age CPF score was lower than that of loading, Health Index was calculated based on age only.

### 10.3 Pad-Mounted Transformers Age Distribution

The age distribution is shown in the figure below. Age was available for the entire population. The average age was found to be 17 years.

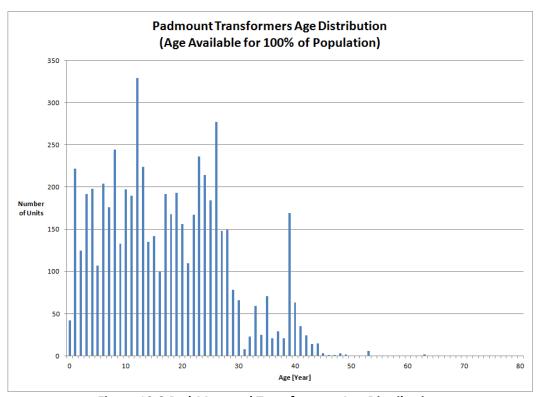


Figure 10-2 Pad-Mounted Transformers Age Distribution

### 10.4 Pad-Mounted Transformers Health Index Results

There are 5906 in-service Pad-Mounted Transformers at Horizon Utilities. The condition assessment is based on age, together with overloading condition calculated using hourly data obtained from Horizon Utilities Smart Meters.

The average Health Index for this asset group is 99%. Less than 1% of the units were found to be in poor or very poor condition.

The Health Index Results are as follows:

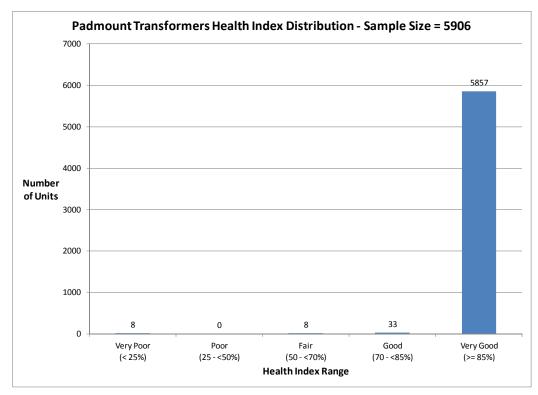


Figure 10-3 Pad-Mounted Transformers Health Index Distribution (Number of Units)

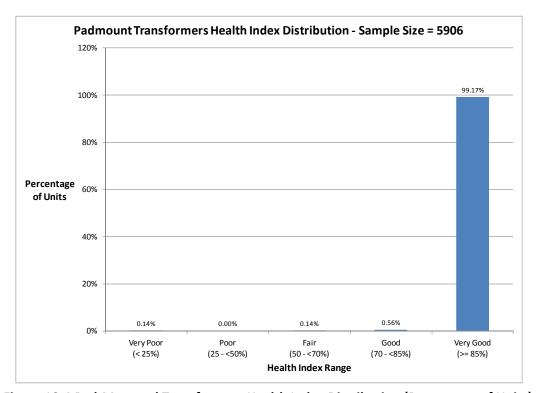


Figure 10-4 Pad-Mounted Transformers Health Index Distribution (Percentage of Units)

The following diagrams show the Pad-Mounted Transformers Health Index distribution by different voltage levels.

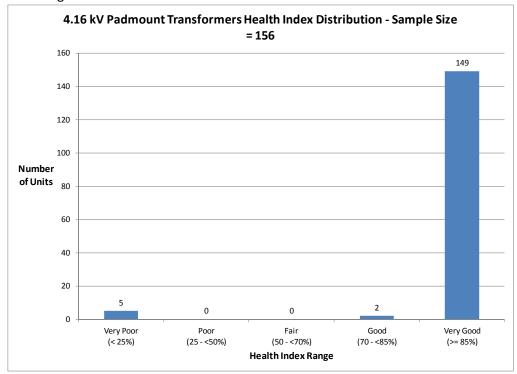


Figure 10-5 Pad-Mounted Transformers Health Index Distribution – 4.16 kV

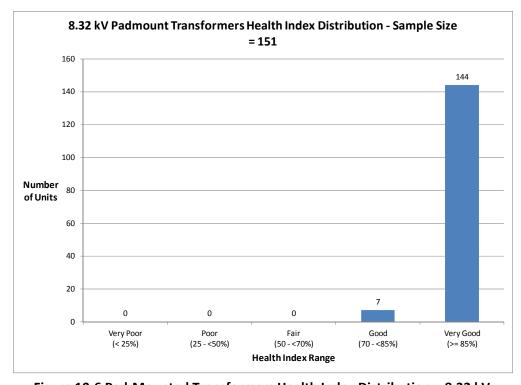


Figure 10-6 Pad-Mounted Transformers Health Index Distribution – 8.32 kV

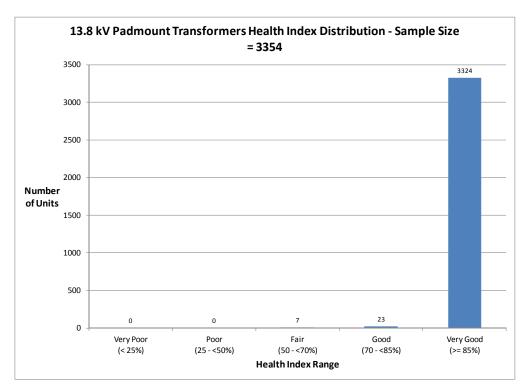


Figure 10-7 Pad-Mounted Transformers Health Index Distribution - 13.8 kV

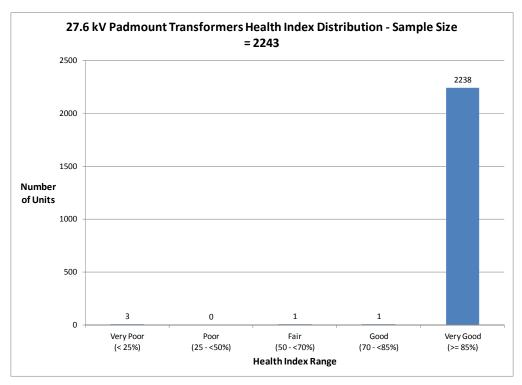


Figure 10-8 Pad-Mounted Transformers Health Index Distribution – 27.6 kV

### 10.5 Pad-Mounted Transformers Condition-Based Flagged-For-Action Plan

As it is assumed that Pad-Mounted Transformers are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate, f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

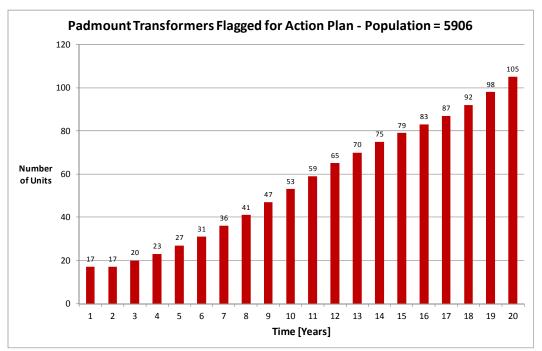


Figure 10-9 Pad-Mounted Transformers Condition-Based Flagged-For-Action Plan

### 10.6 Pad-Mounted Transformers Data Analysis

The data available for Pad-Mounted Transformers includes age and loading determined using hourly data obtained from Horizon Utilities Smart Meter data.

VI - Appendix A: Results and Findings for Each Asset Category

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# 11 Pad Mounted Switchgear

This asset class consists of pad-mounted above grade switchgear typically used in underground distribution systems. The switchgear consists of a low profile pad-mounted enclosure with various internal compartments housing cable terminations, switching, and protection equipment.

The pad-mounted gear can be sub-classified as live-front (with exposed electrical components when the doors are opened) or dead-front (with no live parts exposed). The majority of live-front pad mounted switchgear currently in use includes air-insulated gang-operated load-break switches. Dead-front gear utilizes separable insulated connectors and sometimes oil vacuum or SF6 switches.

#### 11.1 Pad Mounted Switchgear Degradation Mechanism

Pad-mounted switchgear degradation can be caused by:

- Mechanical wear and misalignment
- Moisture ingress
- Contamination of internal components
- Corrosion e.g. rusting of the enclosures or operating mechanism
- Degradation of insulated barriers and breakage of insulators
- Failure of internal components such as insulators and fuses

Mechanical wear is impacted by factors such as frequency of switching operations, and the magnitude of continuous and switched load. Moisture and contamination problems are influenced by the dampness of the installation site and the presence of a corrosive environment.

Failures of switchgear can be associated instead with outside influences. For example, padmounted switchgear can be damaged by rodents and vehicle accidents. There are other defects that are important and require intervention, but do not result into a failure and can be rectified by field action. For example, graffiti on pad-mounted switchgear is often considered an eyesore and may even conceal important safety and operating signage. Re-painting the outside of the case and replacing the signage can usually be done with no disruption of power. In areas with recurring problems, anti-graffiti paint may be an effective solution.

Some of the degradation modes can be mitigated, failures avoided, and life can be extended with good design and maintenance practices. Rusting of a pad-mounted switchgear enclosure can lead to perforation and a public safety hazard. Touch-up and re-painting may delay the rusting process, but eventually a planned replacement of the equipment will be required. Accumulation of dirt and pollution can often be removed by cleaning. On-line cleaning using CO2 or dry ice is one of the technologies used successfully. Inspection and thermo-graphic analysis can detect loose or degrading connections. If problems or defects are identified during inspection, often the affected component can be replaced or repaired without a total replacement of the switchgear.

The first generation of pad mounted switchgear was first introduced in early 1970's and many of these units are still in good operating condition. In the absence of specifically identified problems, the common industry practice for distribution switchgear is running it to end of life, just short of failure.

Consequences of pad-mounted switchgear failure include customer interruptions, health and safety as well as environmental consequences. For instance failures caused by fuse malfunctions can result in a catastrophic pad-mounted switchgear failure.

#### 11.2 Pad Mounted Switchgear Health Index Formula

This section presents the Health Index Formula that was developed and used for Horizon Utilities Pad Mounted Switchgear. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 11.2.1 Pad Mounted Switchgear Condition and Sub-Condition Parameters

**Table 11-1 Condition Parameter and Weights** 

| m Condition Parameter |                       | WCP <sub>m</sub> | <b>Sub-Condition Parameters</b> |  |
|-----------------------|-----------------------|------------------|---------------------------------|--|
| 1 Physical Condition  |                       | 4                | Table 11-2                      |  |
| 2                     | Switch/Fuse Condition | 2                | Table 11-3                      |  |
| 3                     | Insulation            | 2                | Table 11-4                      |  |
| 4                     | Service Record        | 1                | Table 11-5                      |  |

Table 11-2 Physical Condition Sub-Condition Parameters and Weights (m=1)

| n                | Sub-Condition Parameter                 | WCPF <sub>n</sub> | Condition Criteria Table |
|------------------|---|-------------------|--------------------------|
| 1                | 1 Physical Condition (Rust, Paint etc.) |                   | Table 11-6               |
| 2                | Door Hinges                             | 1                 | Table 11-6               |
| 3 Pad Foundation |   | 1                 | Table 11-6               |

Table 11-3 Switch/Fuse Sub-Condition Parameters and Weights (m=2)

| 14510 12 5 5 111ton / 1450 545 55 141ton 141 |                         |                   |                          |  |
|--|-------------------------|-------------------|--------------------------|--|
| n  | Sub-Condition Parameter | WCPF <sub>n</sub> | Condition Criteria Table |  |
| 1  | Switch Blades           | 3                 | Table 11-6               |  |
| 2  | Arc Suppressor 3 Tab    |                   | Table 11-6               |  |
| 3  | Cable Termination       | 1                 | Table 11-6               |  |
| 4  | Grounding               | 1                 | Table 11-6               |  |
| 5  | Hot Spot in IR Scan     | 2                 | Table 11-7               |  |

Table 11-4 Insulation Sub-Condition Parameters and Weights (m=3)

| n | Sub-Condition Parameter  | WCPF <sub>n</sub> | Condition Criteria Table |
|---|--------------------------|-------------------|--------------------------|
| 1 | Support/Switch Insulator | 2                 | Table 11-6               |
| 2 | Barrier Boards           | 1                 | Table 11-6               |

Table 11-5 Service Record Sub-Condition Parameters and Weights (m=4)

| n | Sub-Condition Parameter | WCPF <sub>n</sub> | Condition Criteria Table |
|---|-------------------------|-------------------|--------------------------|
| 1 | Other                   | 1                 | Table 11-6               |
| 2 | Age                     | 2                 | Figure 11-1              |

### 11.2.2 Pad Mounted Switchgear Condition Criteria

### **Visual Inspections**

**Table 11-6 Inspection Condition Criteria** 

| Condition<br>Rating* | CPF | Description          |  |
|----------------------|-----|----------------------|--|
| Α                    | 4   | PASS                 |  |
| С                    | 2   | PASS (Not Unique ID) |  |
| E                    | 0   | Failed               |  |

**Table 11-7 IR Condition Criteria** 

| Condition<br>Rating* | CPF | Description (Hot Spot Detected) |
|----------------------|-----|---------------------------------|
| Α                    | 4   | FALSE                           |
| Е                    | 0   | TRUE                            |

#### Age

Assume that the failure rate Pad Mounted Switchgear exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure Assuming that at the ages of 40 and 55 years the probability of failures ( $P_f$ ) for this asset are 50% and 80% respectively results in the survival curve shown below. It follows that the Score for Age is the survival curve normalized to the maximum Score of 4 (i.e. 4\*Survival Curve). The Score vs. Age is also shown in the figure below.

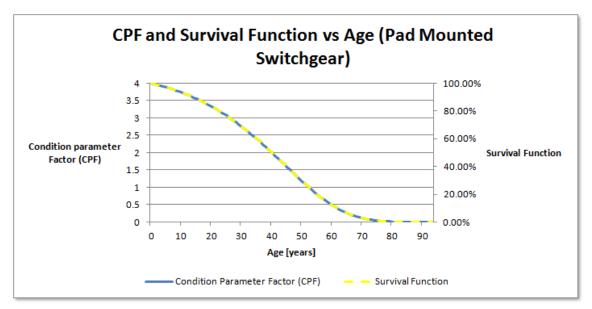


Figure 11-1 Age Criteria (Pad Mounted Switchgear)

### 11.3 Pad Mounted Switchgear Age Distribution

The age distribution is shown in the figure below. Age was available for the entire population. The average age was found to be 23 years.

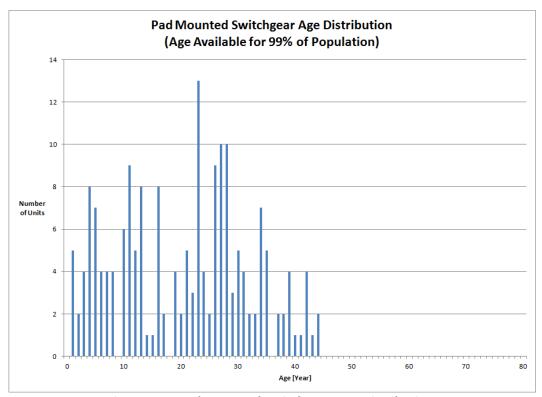


Figure 11-2 Pad Mounted Switchgear Age Distribution

# 11.4 Pad Mounted Switchgear Health Index Results

There are 186 in-service Pad Mounted Switchgear at Horizon Utilities. Most of them have age and inspection data available for assessment.

The average Health Index for this asset group is 77%. Approximately 4% of the units were found to be in poor condition.

The Health Index Distribution is shown in the following tables.

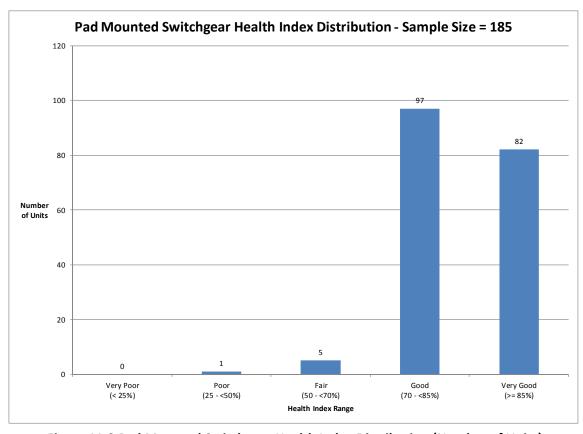


Figure 11-3 Pad Mounted Switchgear Health Index Distribution (Number of Units)

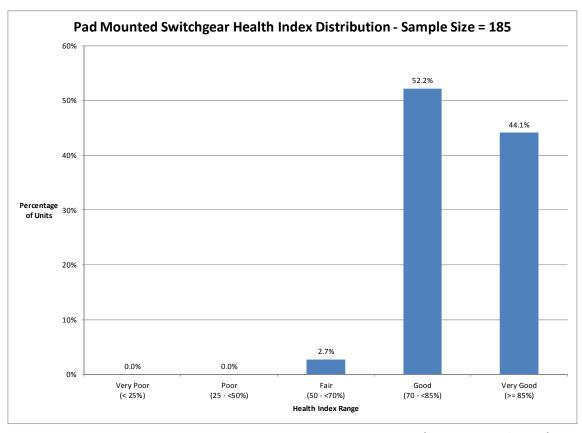


Figure 11-4 Pad Mounted Switchgear Health Index Distribution (Percentage of Units)

### 11.5 Pad Mounted Switchgear Condition-Based Flagged-For-Action Plan

As it is assumed that Pad Mounted Switchgear is reactively replaced, the risk assessment and replacement procedure described in Section II.2.2 was applied for this asset class.

The optimal Flagged-For-Action Plan is based on the number of expected failures in a given year.

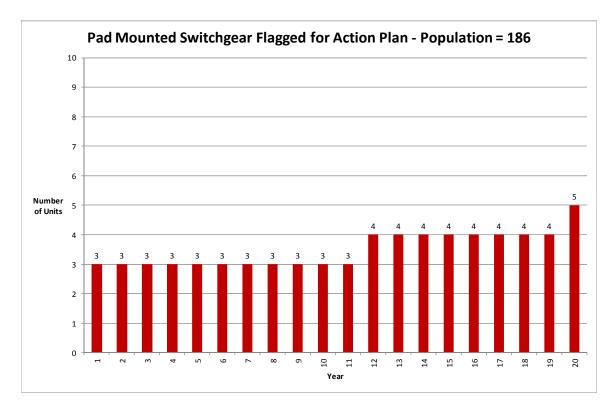


Figure 11-5 Pad Mounted Switchgear Optimal Condition-Based Flagged-For-Action Plan

### 11.6 Pad Mounted Switchgear Data Analysis

The data available for Pad Mounted Switchgear includes age, location and inspection records. Horizon Utilities should continue with the existing practices.

VI - Appendix A: Results and Findings for Each Asset Category

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#### 12 Vault Transformers

Vault-type distribution transformers are generally installed in a dedicated compartment in a building or under a sidewalk in locations where there is not sufficient room for a pad-mounted transformer. Vault-type transformers are often used in secondary networks and spot networks. They are available for primary voltages from 1.2 to 34.5kV in ratings generally up to 1000kVA.

As vault transformers are often located in harsh environments, vault transformer design often includes enhancements to the protective coatings on the steel walls. Some vault-type transformers may be used in submersible applications.

#### 12.1 Vault Transformers Degradation Mechanism

Degradation of vault-type transformers can occur due to the following mechanisms:

- Corrosion of the tank
- Deterioration of internal switching or fusing devices
- Degradation of internal insulating material
- Degradation of oil

Vault-type transformers are often located in corrosive below-grade environments and are prone to enclosure corrosion. Deterioration of the vault-type transformer can also be due to problems such as: switch breakage and leakage of under-oil fuses.

The life of the transformer's internal insulation is related to temperature-rise and duration. Therefore, transformer life is affected by electrical loading profiles and length of service life. The impacts of loading profiles, load growth, and ambient temperature on asset condition, loss-of-life, and life expectancy can be assessed using methods outlined in ANSI\IEEE Loading Guides. This also provides an initial baseline for the size of transformer that should be selected for a given number and type of customers to obtain optimal life.

Visual inspections provide considerable information on transformer asset condition. Leaks, rusting, and deteriorated connectors can all be established by visual inspections. Transformer oil testing can be employed for distribution transformers to assess the condition of solid and liquid insulation.

The consequences of vault—type transformer failure can be severe because of the in-building or under side-walk location of this equipment. Though rare, vault-type transformers can fail with sufficient energy release to rupture the tank and release oil into the surroundings.

#### 12.2 Vault Transformers Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Vault Transformers. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

## 12.2.1 Vault Transformers Condition and Sub-Condition Parameters

**Table 12-1 Vault Transformers Condition Parameter and Weights** 

| m | Condition Parameter       | WCP <sub>m</sub> | <b>Sub-Condition Parameters</b> |
|---|---------------------------|------------------|---------------------------------|
| 1 | Service Record            | 1                | Table 12-2                      |
|   | De-rating multiplier (DR) |                  | Table 12-4                      |

Table 12-2 Vault Transformers Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition<br>Parameter | CPF Lookup Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|----------------------------|------------------|-------------------|----------------------|
| 1 | Loading                    | Table 12-3       | 1                 | 4                    |
| 2 | Age                        | Figure 12-1      | 2                 | 4                    |

#### 12.2.2 Vault Transformers Condition Criteria

#### **Age**

Assume that the failure rate for Vault Transformers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function

 $P_f$  = probability of failure

Assuming that at the ages of 40 and 45 years the probability of failure ( $P_f$ ) for this asset are 80% and 90% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

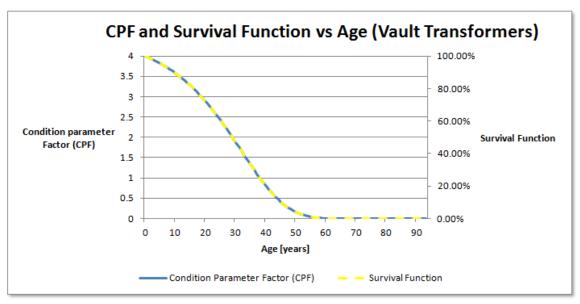


Figure 12-1 Age Condition Criteria (Vault Transformers)

## Loading

**Table 12-3 Vault Transformers Loading History** 

Data: S1, S2, S3, ..., SN recorded data (monthly 15 min peak)

SB= rated MVA

NA=Number of Si/SB which is lower than 1.0

NB= Number of Si/SB which is between 1 and 1.2

NC= Number of Si/SB which is greater than 1.2

$$\mathsf{CPF} = \frac{NA \times 4 + NB \times 1 + NC \times 0}{N}$$

Hourly transformer loading was used to determine overloading occurrences leading to a loss of life and thereby increasing the effective age of the transformer. Transformer loading was not determined to decrease the effective age of the transformer in the absence of overloading occurrences. Therefore, loading condition was incorporated only when the loading CPF score was less than age CPF score for a transformer. In the cases when age CPF score was lower than that of loading, Health Index was calculated based on age only.

## **De-Rating (DR) Multiplier**

**Table 12-4 Vault Transformers De-Rating Factors** 

| De-Rating<br>Factor | Description  |
|---------------------|--|
| 0.8                 | All the vault transformers due to obsolescence/safety concerns |

## 12.3 Vault Transformers Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 25 years.

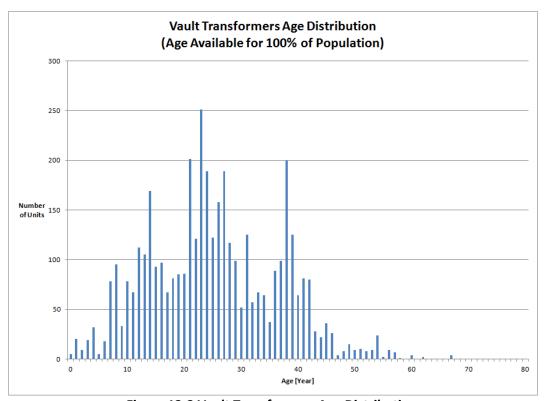


Figure 12-2 Vault Transformers Age Distribution

#### 12.4 Vault Transformers Health Index Results

There are 4169 in-service Vault Transformers at Horizon Utilities. The condition assessment is based on age, together with overloading condition calculated using hourly data obtained from Horizon Utilities Smart Meters. Additionally, all vault transformers were de-rated due to their obsolescence and safety concerns.

The average Health Index for this asset group is 46%. Approximately 20% of the units were found to be in poor or very poor condition due mainly to the de-rating factor applied.

The Health Index Results are as follows:

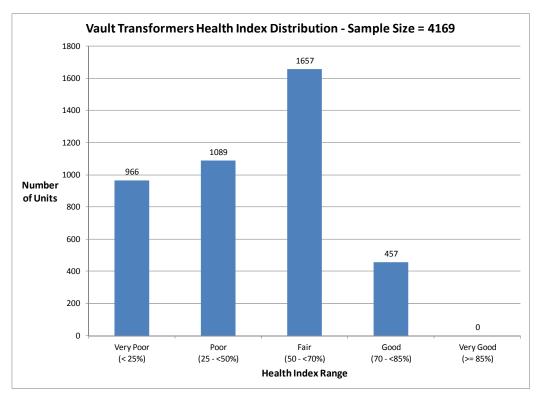


Figure 12-3 Vault Transformers Health Index Distribution (Number of Units)

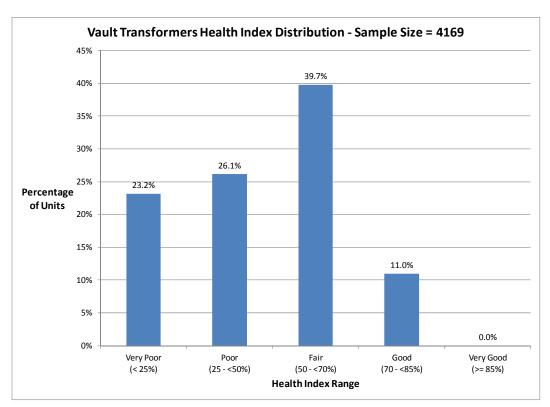


Figure 12-4 Vault Transformers Health Index Distribution (Percentage of Units)

The following diagrams show the Vault Transformers Health Index distribution by different voltage levels.

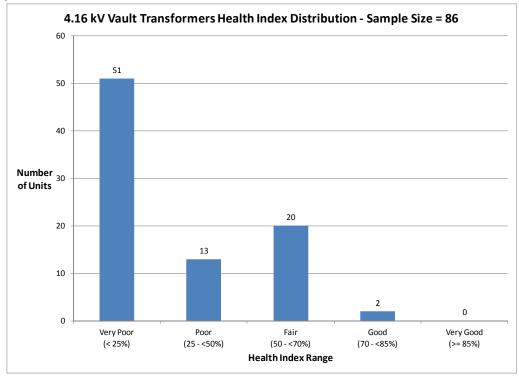


Figure 12-5 Vault Transformers Health Index Distribution – 4.16 kV

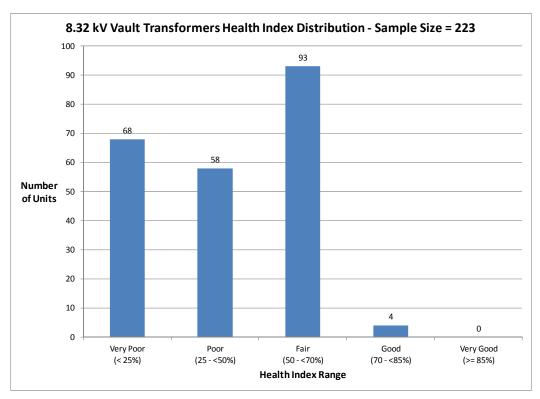


Figure 12-6 Vault Transformers Health Index Distribution – 8.32 kV

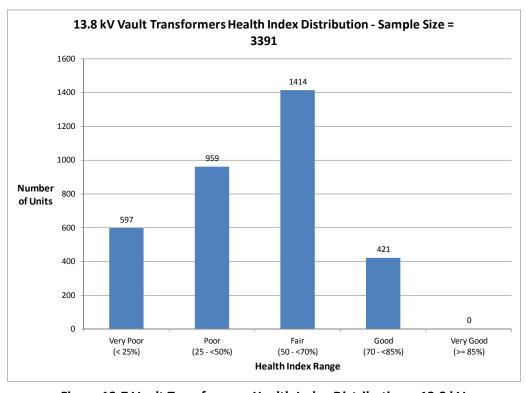


Figure 12-7 Vault Transformers Health Index Distribution – 13.8 kV

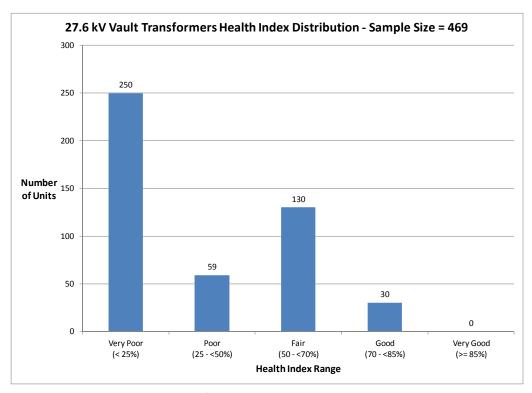


Figure 12-8 Vault Transformers Health Index Distribution - 27.6 kV

## 12.5 Vault Transformers Condition-Based Flagged-For-Action Plan

As it is assumed that Vault Transformers are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

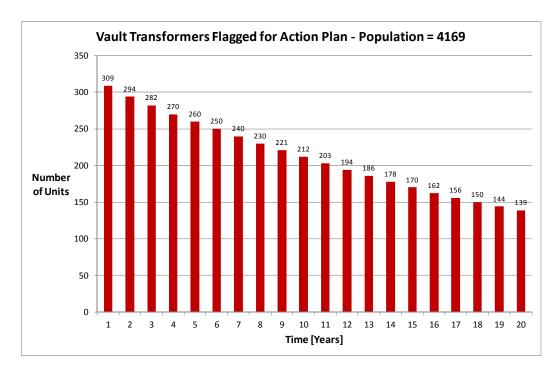


Figure 12-9 Vault Transformers Condition-Based Flagged-For-Action Plan

## 12.6 Vault Transformers Data Analysis

The data available for Vault Transformers includes age and loading determined using hourly data obtained from Horizon Utilities Smart Meter data.

VI - Appendix A: Results and Findings for Each Asset Category

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## 13 Utility Chambers

Utility Chambers facilitate cable pulling into underground ducts and provide access to splices and facilities that require periodic inspections or maintenance. Below ground equipment vaults permit installation of transformers, switchgear or other equipment. Vaults used for transformer installation are often equipped with ventilation grates to provide natural or forced cooling.

Underground cable chambers come in different styles, shapes and sizes according to the location and application. For this analysis we identified only the broad categories depending on their use and type of construction. Precast cable chambers are normally installed only outside the traveled portion of the road although some end up under the road surface after road widening. Cast-in-place cable chambers are used under the traveled portion of the road because of their strength and also because they are cheaper to rebuild if they should fail. Customer cable chambers are on customer property and are usually in a more benign environment. Although they supply a specific customer, system cables loop through these chambers so other customers could also be affected by any problems. Sidewalk vaults are most often located in or adjacent to pedestrian walkways.

#### 13.1 Utility Chambers Degradation Mechanism

Utility chambers must withstand the heaviest structural loadings that they might be subjected to. For example, when located in streets, utility chambers must withstand heavy loads associated with traffic in the street. When located in driving lanes, manhole chimney and collar rings must match street grading. Since utility chambers and vaults often experience flooding, they sometimes include drainage sumps and sump pumps. However, environmental regulations in some jurisdictions may prohibit the pumping of utility chambers or vaults into sewer systems, without testing of the water for environmentally hazardous contaminants.

Although age is loosely related to the condition of underground civil structures, it is not a linear relationship. Other factors such as mechanical loading, exposure to corrosive salts, etc. have a stronger effect. Therefore, a condition-based asset management program based on periodic field inspections to identify problems and rate the condition of the structure is used by many utilities. Tracking the results of these inspections will show the rate of deterioration and provide advance notice of impending work to correct any problems. Some underground chambers may only need cleaning or repairs to frames and covers or vault doors and grates, but the others may require major rebuilding of the walls and/or roof.

Utility chamber degradation commonly includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers or rings. Acidic salts (i.e. sulfates or chlorides) affect corrosion rates. Manhole systems also may experience a number of deficiencies or defects. In roadways, defects exist when covers are not level with street surfaces. Conditions that lead to flooding, clogged sumps, and non-functioning sump-pumps also represent major deficiencies in a manhole system. Similarly, manhole systems with lights that do not function properly constitute defective systems. Deteriorating ductwork associated with utility chambers also requires evaluation in assessing the overall condition of a manhole system. In addition to the above, for

equipment vaults, the condition of ventilation grates and padlocks need to be considered in assessing overall health.

## 13.2 Utility Chambers Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Utility Chambers. The Health Index equation is shown in Section II.1; the condition, subcondition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

### 13.2.1 Utility Chambers Condition and Sub-Condition Parameters

**Table 13-1 Utility Chambers Condition Parameter and Weights** 

| m | m Condition Parameter |   | <b>Sub-Condition Parameters</b> |
|---|-----------------------|---|---------------------------------|
| 1 | Service Record        | 2 | Table 13-2                      |

Table 13-2 Utility Chambers Service Record (m=5) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Overall                 | Table 13-3          | 1                 | 4                    |
| 2 | Age                     | Figure 13-1         | 2                 | 4                    |

#### 13.2.2 Utility Chambers Condition Criteria

## **Overall Condition**

**Table 13-3 Utility Chambers Overall Condition Criteria** 

| Condition<br>Rating* | CPF | Description (Kinectrics 2011 report) |
|----------------------|-----|--------------------------------------|
| Α                    | 4   | A                                    |
| В                    | 3   | В                                    |
| С                    | 2   | С                                    |
| D                    | 1   | D                                    |
| Е                    | 0   | E                                    |

#### Age

Assume that the failure rate for Utility Chambers exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 80 and 95 years the probability of failure ( $P_f$ ) for this asset are 50% and 85% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

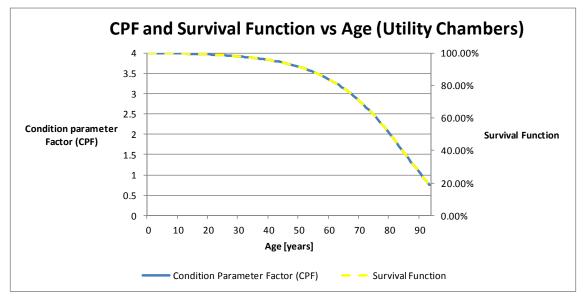


Figure 13-1 Age Condition Criteria (Utility Chambers)

#### 13.3 Utility Chambers Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 39 years.

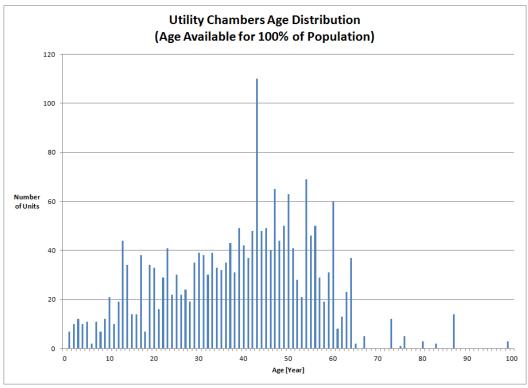


Figure 13-2 Utility Chambers Age Distribution

## 13.4 Utility Chambers Health Index Results

There are 2075 in-service Utility Chambers at Horizon Utilities. The condition assessment for utility chambers is primarily age-driven. Results of an independent assessment performed on a sample of utility chambers were included in the condition assessment.

The average Health Index for this asset group is 92%.

The Health Index Results are as follows:

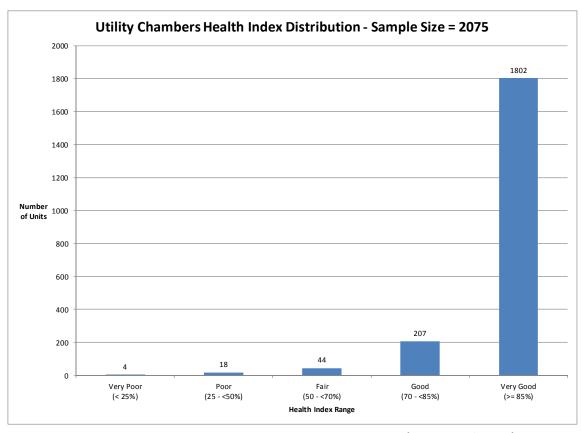


Figure 13-3 Utility Chambers Health Index Distribution (Number of Units)

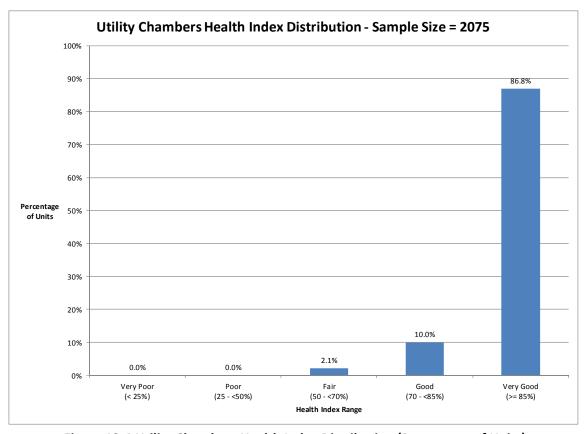


Figure 13-4 Utility Chambers Health Index Distribution (Percentage of Units)

## 13.5 Utility Chambers Condition-Based Flagged-For-Action Plan

As it is assumed that Utility Chambers are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

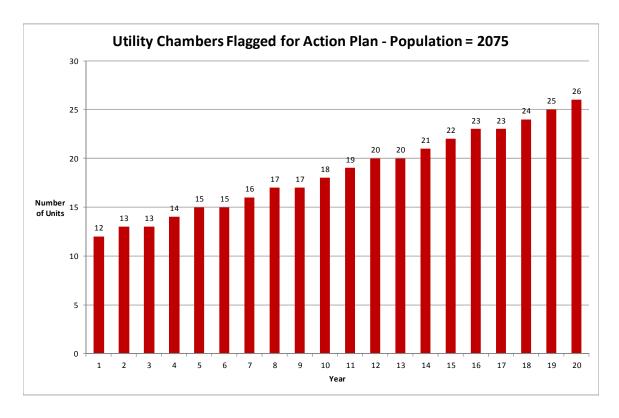


Figure 13-5 Utility Chambers Optimized Condition-Based Flagged-For-Action Plan

## 13.6 Utility Chambers Data Analysis

The data available for Utility Chambers includes age and Kinectrics assessment sample records (for very few units using remotely controlled camera). It is recommended to conduct periodic assessments to increase the sample size, particularly to include locations deemed to be critical by Horizon Utilities.

## 14 Vaults

There are 3143 vaults included in this report. Similar to Utility Chambers, vaults facilitate cable pulling into underground ducts and provide access to splices and facilities that require periodic inspections or maintenance. At Horizon Utilities, vaults are typically smaller than Utility Chambers and utilized where regular access for workers is not required.

Underground vaults come in different styles, shapes and sizes according to the location and application. For this analysis we identified only the broad categories depending on their use and type of construction.

#### 14.1 Vaults Degradation Mechanism

Vaults must withstand the heaviest structural loadings that they might be subjected to. For example, when located in streets, vaults must withstand heavy loads associated with traffic in the street. When located in driving lanes, manhole chimney and collar rings must match street grading. Since vaults often experience flooding, they sometimes include drainage sumps and sump pumps. However, environmental regulations in some jurisdictions may prohibit the pumping of vaults into sewer systems, without testing of the water for environmentally hazardous contaminants.

Although age is loosely related to the condition of underground civil structures, it is not a linear relationship. Other factors such as mechanical loading, exposure to corrosive salts, etc. have a stronger effect. Therefore, a condition-based asset management program based on periodic field inspections to identify problems and rate the condition of the structure is used by many utilities. Tracking the results of these inspections will show the rate of deterioration and provide advance notice of impending work to correct any problems. Some underground vaults may only need cleaning or repairs to frames and covers or vault doors and grates, but the others may require major rebuilding of the walls and/or roof.

Vault degradation commonly includes corrosion of reinforcing steel, spalling of concrete, and rusting of covers or rings. Acidic salts (i.e. sulfates or chlorides) affect corrosion rates. Manhole systems also may experience a number of deficiencies or defects. In roadways, defects exist when covers are not level with street surfaces. Conditions that lead to flooding, clogged sumps, and non-functioning sump-pumps also represent major deficiencies in a manhole system. Similarly, manhole systems with lights that do not function properly constitute defective systems. Deteriorating ductwork associated with vaults also requires evaluation in assessing the overall condition of a manhole system. In addition to the above, for equipment vaults, the condition of ventilation grates and padlocks need to be considered in assessing overall health.

#### 14.2 Vaults Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Vaults. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

Assume a parameter scoring system of 0 through 4, where 0 and 4 represent the "worst" and "best" scores respectively. Thus, the maximum score for any condition or sub-condition parameter (maximum CPS and CPF) is "4".

#### 14.2.1 Vaults Condition and Sub-Condition Parameters

**Table 14-1 Vaults Condition Parameter and Weights** 

| m | Condition Parameter | WCP <sub>m</sub> | Sub-Condition Parameters |
|---|---------------------|------------------|--------------------------|
| 1 | Service Record      | 1                | Table 14-2               |

Table 14-2 Vaults Service Record (m=1) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>Table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Age                     | Figure 15-1         | 1                 | 4                    |

#### 14.2.2 Vaults Condition Criteria

### <u>Age</u>

Assume that the failure rate for Vaults exponentially increases with age and that the failure rate equation is as follows:

$$f=e^{\beta(t-\alpha)}$$

f = failure rate of an asset (percent of failure per unit time)

t = time

 $\alpha$ ,  $\beta$  = constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure Assuming that at the ages of 80 and 95 years the probability of failure ( $P_f$ ) for this asset are 50% and 85% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

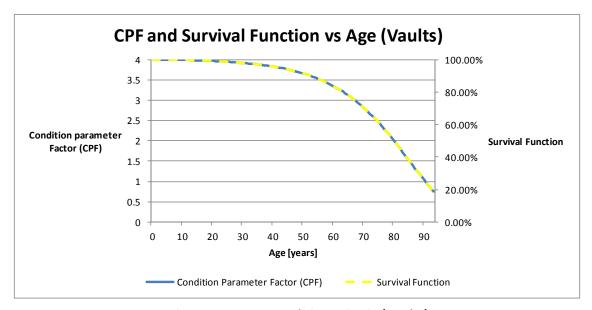


Figure 14-1 Age Condition Criteria (Vaults)

## 14.3 Vaults Age Distribution

The age distribution is shown in the figure below. Age was available for 100% of the population. The average age was found to be 28 years.

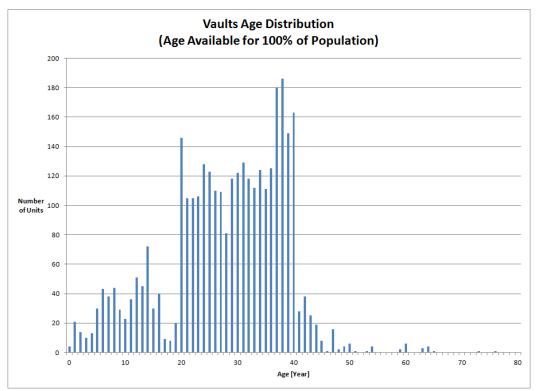


Figure 14-2 Vaults Age Distribution

## 14.4 Vaults Health Index Results

There are 3143 in-service Vaults at Horizon Utilities. The Health Index is exclusively age driven.

The average Health Index for this asset group is 97%. None of the units was found to be in poor or very poor condition.

The Health Index Results are as follows:

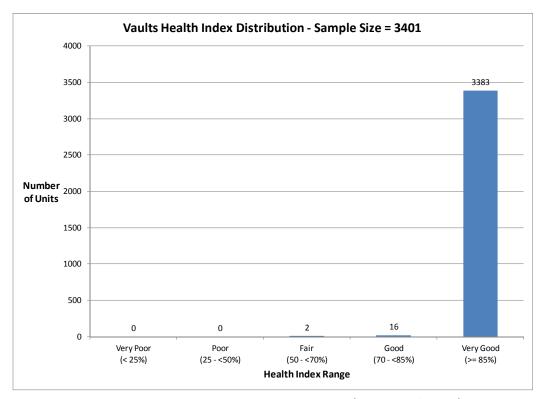


Figure 14-3 Vaults Health Index Distribution (Number of Units)

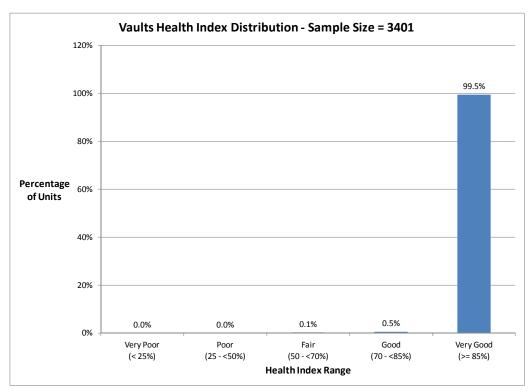


Figure 14-4 Vaults Health Index Distribution (Percentage of Units)

## 14.5 Vaults Condition-Based Flagged-For-Action Plan

As it is assumed that Vaults are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

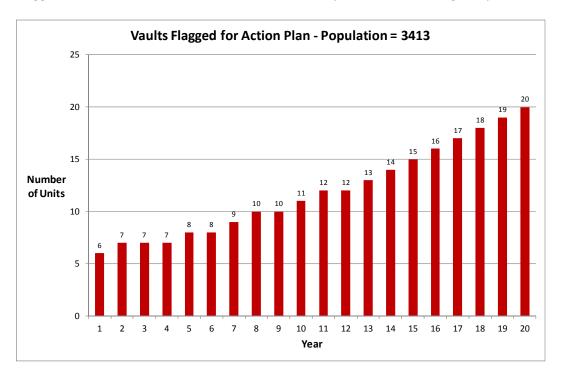


Figure 14-5 Vaults Condition-Based Flagged-For-Action Plan

## 14.6 Vaults Data Analysis

The data available for Vaults includes age only.

#### 15 Submersible Load Break Switches

This asset group consists of distribution underground three-phase gang operated switches, manually operated as well as motor operated. The primary function of switches is to permit isolation of line sections or equipment for maintenance, safety or other operating requirements. While some categories of switches are rated for load interruption, others are designed to operate under no load conditions, these switches operate only when the current through the switch is zero.

In general, submersible load break switches consist of mechanically movable copper blades supported on insulators and mounted inside a sealed unit. The insulating medium is either oil or SF<sup>6</sup>. The operating or control mechanism can be either a simple hook stick or a manual gang. Since they do not typically need to interrupt short circuit currents, disconnect switches are relatively simple in design compared to circuit breakers.

#### 15.1 Submersible Load Break Switches Degradation Mechanism

The main degradation processes associated with line switches include:

- Corrosion of steel hardware or operating rod
- Contamination of oil for oil insulated devices
- Degradation of the separable connectors

The rate and severity of these degradation processes depends on a number of inter-related factors including the operating duties and environment in which the equipment is installed. In most cases, corrosion or rust represents a critical degradation process. The rate of deterioration depends heavily on environmental conditions where the equipment operates.

#### 15.2 Submersible Load Break Switches Health Index Formulation

This section presents the Health Index Formula that was developed and used for Horizon Utilities Submersible Load Break Switches. The Health Index equation is shown in Section II.1; the condition, sub-condition parameters, weights, and condition criteria are as follows.

#### 15.2.1 Submersible Load Break Switches Condition and Sub-Condition Parameters

Table 15-1 Submersible Load Break Switches Condition Weights and Maximum CPS

| m | Condition Parameter | WCP <sub>m</sub> | CPS Lookup Table |
|---|---------------------|------------------|------------------|
| 1 | Service Record      | 1                | Table 15-1       |
|   | De-rating multipli  |                  |                  |

Table 15-1 Submersible Load Break Switches Service Record (m=3) Weights and Maximum CPF

| n | Sub-Condition Parameter | CPF Lookup<br>table | WCPF <sub>n</sub> | CPF <sub>n.max</sub> |
|---|-------------------------|---------------------|-------------------|----------------------|
| 1 | Age                     | Figure 15-1         | 1                 | 4                    |

#### 15.2.2 Submersible Load Break Switches Condition Parameter Criteria

#### Age

Assume that the failure rate for Submersible Load Break Switches exponentially increases with age and that the failure rate equation is as follows:

$$f = e^{\beta(t-\alpha)}$$

= failure rate of an asset (percent of failure per unit time)

= constant parameters that control the rise of the curve

The corresponding survivor function is therefore:

$$S_f = 1 - P_f = e^{-(f - e^{-\alpha\beta})/\beta}$$

 $S_f$  = survivor function  $P_f$  = probability of failure

Assuming that at the ages of 40 and 50 years the probability of failure (P<sub>f</sub>) for this asset are 50% and 80% respectively results in the survival curve shown below. It follows that the CPF for Age is the survival curve normalized to the maximum CPF score of 4 (i.e. 4\*Survival Curve). The CPF vs. Age is also shown in the figure below:

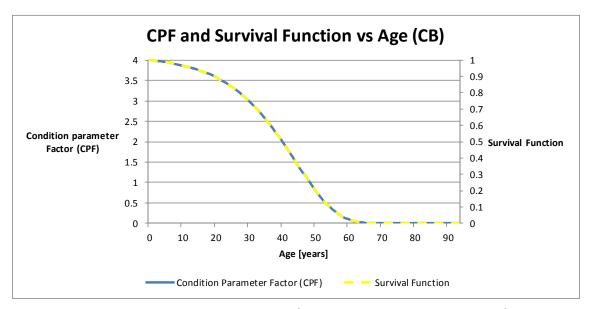


Figure 15-1 Age Condition Criteria (Submersible Load Break Switches)

## **De-Rating (DR) Multiplier**

The de-rating is based on the following equation:

$$DR = \min(DRF_1, DRF_2, DRF_3)$$

**Equation 15-1** 

Where DRF are as described as follows:

**Table 15-2 Submersible Load Break Switches De-Rating Factors** 

| De-Rating<br>Factor (DRF) | De-Rating Factor | Description                         |
|---------------------------|------------------|-------------------------------------|
| DRF <sub>1</sub>          | 0.7              | Old oil LBDS (older than year 2000) |

## 15.3 Submersible Load Break Switches Age Distribution

The age distribution is shown in the figures below. Age was available for 100% of the population. The average age was found to be 30 years.

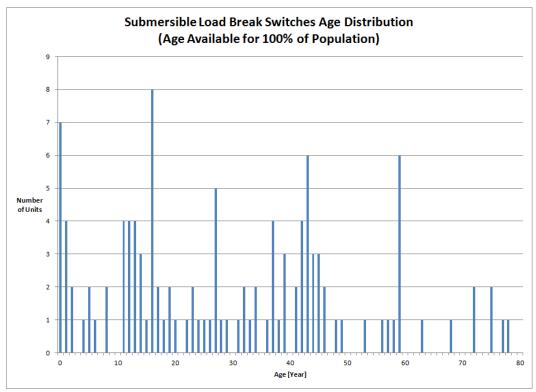


Figure 15-2 Submersible Load Break Switches Age Distribution

## 15.4 Submersible Load Break Switches Health Index Results

There are 117 in-service Submersible Load Break Switches at Horizon Utilities. The condition assessment is age-driven. The average Health Index for this asset group is 55%. Approximately 46% of the switches were found to be in poor or very poor condition.

The Health Index Results are as follows:

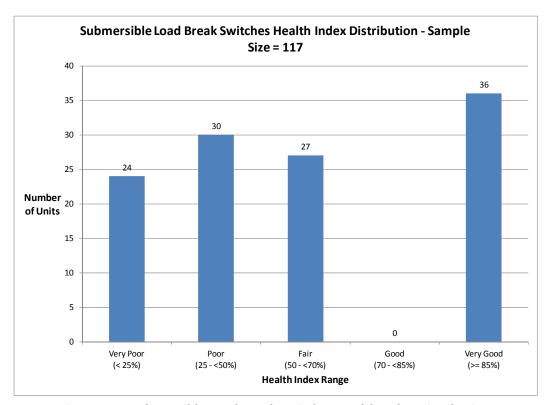


Figure 15-3 Submersible Load Break Switches Health Index Distribution

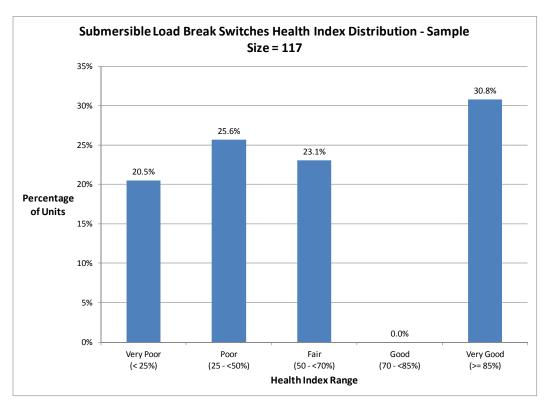


Figure 15-4 Submersible Load Break Switches Health Index Distribution

## 15.5 Submersible Load Break Switches Condition-Based Flagged-For-Action Plan

As it is assumed that Submersible Load Break Switches are reactively replaced, the Flagged-For-Action Plan is based on asset failure rate f (t), as described in Section II.2.2.

The Flagged-For-Action Plan is based on the number of expected failures in a given year.

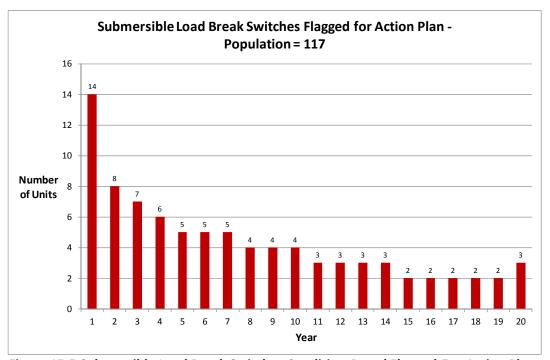


Figure 15-5 Submersible Load Break Switches Condition-Based Flagged-For-Action Plan

## 15.6 Submersible Load Break Switches Data Analysis

The data available for Submersible Load Break Switches included age only.

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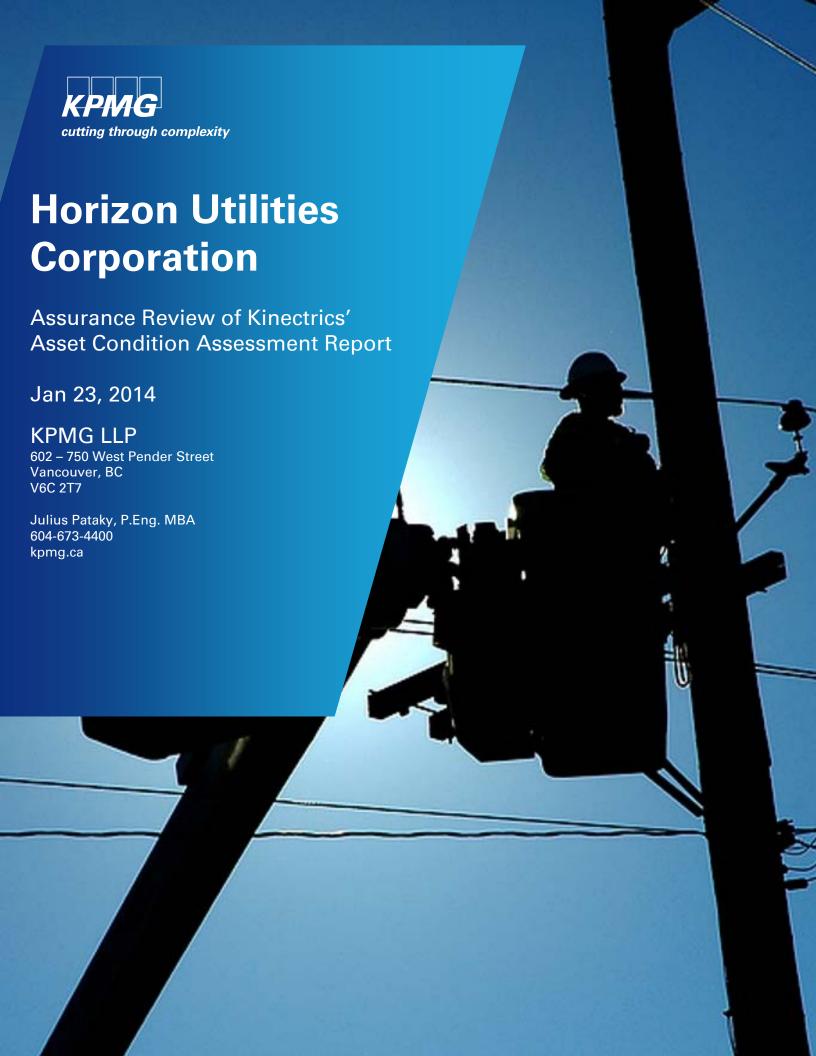
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# <u>Appendix C – KPMG Assurance Review of Kinectrics' Asset Condition</u> <u>Assessment Review</u>





# **Version Control**

| Version | Date         | Ву          | Description                              |
|---------|--------------|-------------|--|
| 0.9     | Dec 18, 2013 | David Cheng | Original Draft for discussion            |
| 1.0     | Jan 21, 2014 | David Cheng | Incorporated Horizon feedback            |
| 1.1     | Jan 23, 2014 | David Cheng | Incorporated additional Horizon feedback |
|         |              |             |  |



## **Glossary**

**Chronological Age** age of the asset expressed in years since its

installation

**Health Index** condition of the asset expressed as a percentage

score between 0 and 100% with 100%

representing an asset that is in new condition

**Proactive Replacement** a strategy that will flag assets for action based on

the capability of handling a pre-defined stress level, typically resulting in Flagged-for-Action prior

to the physical end of life.

**Reactive Replacement** a strategy that flags assets for action based on

the failure rate of the assets

**Flagged-for-Action** a state that identifies assets to be considered for

replacement or significant refurbishment



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## 1 Executive Summary

Kinectrics Inc. ("Kinectrics") was retained by Horizon between 2012 and 2013 to conduct an assessment on Horizon's distribution assets with the goal of identifying future asset replacement or refurbishment needs in order to sustain the existing assets. Kinectrics findings and recommendations were delivered in their final report dated November 27, 2013 (Kinectrics Inc., 2013).

Based on an independent assurance review of the methodology and analytics used in the Kinectrics report titled "Horizon Utilities 2013 Asset Condition Assessment" (Kinectrics Inc., 2013), it is KPMG's opinion that the approach used to arrive at the presented results is in line with industry practice and generally accepted methodologies. KPMG is of the opinion that the presented methodology has been appropriately and consistently applied against the Horizon Utilities Corporation ("Horizon") supplied asset data in order to derive the final Flagged-for-Action (assets flagged for replacement or refurbishment) plans for each of the asset classes. The interim and final results as presented in the Kinectrics report have been independently validated by KPMG to an acceptable margin of error for the intended purpose of projecting asset replacements or refurbishments over a twenty year period. When compared with accepted industry standards and practices for useful asset life, Kinectrics Flagged-for-Action plans appear to be reasonable and in line with industry expectations.

KPMG was subsequently retained by Horizon as a third party to conduct an independent assurance review and provide an opinion on Kinectrics' methodology and the resultant findings and recommendations contained in their report. KPMG provided advisory services that consisted of inquiry, observation, analysis and comparison of Horizon-provided information. The findings relied on the completeness and accuracy of the information provided. KPMG expresses no opinion on financial results, internal control, data quality or other information.

KPMG reviewed the methodology published by Kinectrics in their report and compared it with other methodologies used in utilities for predicting probabilistic life expectancy of assets in order to test the validity of the selected methodology used by Kinectrics. The probabilistic approach used by Kinectrics to calculate remaining asset life based on asset condition and asset age is consistent with similar models used in other utilities and in actuary science. The inclusion of asset condition in these calculations provides a more sophisticated approach than that of using chronological age alone. Kinectrics also employed different predictive models for run-to-failure assets (reactively replaced) and for assets that are replaced or rehabilitated before failure occurs (proactively managed assets). This differentiated approach is more advanced than that which is currently in use at most other utilities and in theory should provide more appropriate modelling of remaining asset life for reactively replaced assets and for proactively managed assets.

From the described methodology and from the original asset condition data set provided by Horizon to Kinectrics for their assessment, KPMG was successful in recreating independent analytical models to calculate the health indices, effective ages and Flagged-for-Action plans for the 22 distinct classes of assets (see Appendix 1) and comparing them with Kinectrics' published results.

The results calculated by Kinectrics and independently calculated by KPMG are within an acceptable and reasonable margin of error for the intended purpose of projecting asset replacements or refurbishments over a twenty year period. The numbers of units identified for replacement or refurbishment by the two respective models differ by less than 0.5% for 19 out of the 22 asset classes and the remaining 3 asset classes differ by no more than 4.5%. Using current standard unit costs provided by Horizon, the cumulative anticipated investment over twenty years is projected to be \$693.7M for the Kinectrics model and \$694.8M for that of KPMG. The projected twenty year difference is 0.02%; this difference is



insignificant between the two models. Thus, it is KPMG's opinion that Kinectrics has consistently applied their methodology as published in their report using Horizon's asset data.

To test the reasonableness of the effective age calculations, the effective age distribution for each asset class was compared with the chronological age distribution to identify any potential anomalies in applying the asset condition ratings to the asset population. This test demonstrated relative consistency between chronological age and effective age distributions for 21 out of the 22 asset classes. The Substation Transformers asset class was the only exception found; its average effective age was found to be significantly below the average chronological age. The result of this age reduction is that this asset class would require less capital sustainment investments going forward than if the chronological age was the only criterion used. Using the effective age distribution, the investment impact would be understated when compared to using the chronological age distribution. This lower level of investment is reflected in the resultant Flagged-for-Action plan for Substation Transformers.

To further test the reasonableness of the Kinectrics results, a comparison of their Flagged-for-Action plan was made against an alternative plan generated from accepted asset life expectancies found in the Asset Depreciation Study for the Ontario Energy Board (OEB) report (Kinectrics Inc. Report No: K-418033-RA-001-R000, 2010). Using the published useful life expectancy data for the different asset classes found in the Asset Depreciation Study against the chronological ages of the assets, an alternative twenty year investment plan was created by KPMG. This alternative OEB-based investment plan was compared to the one created by Kinectrics. The twenty year investment plan based on the OEB data projected \$706.9M required capital investment versus the \$693.7M figure projected by Kinectrics. The marginal differences between these two models validated that Kinectrics' projections are within accepted industry norms and practices for asset replacements or refurbishments.

In conclusion, it is KPMG's opinion that the approach and the calculations used to arrive at the presented results in the Kinectrics report is in line with industry practice and generally accepted methodologies.



## 2 Introduction

In 2012, Horizon commissioned Kinectrics to conduct an asset condition assessment on Horizon's distribution assets with the goal of identifying future investments needed to sustain Horizon's existing asset base. Kinectrics' findings and recommendations have been published in the Horizon Utilities 2013 Asset Condition Assessment report (the "report") (Kinectrics Inc., 2013). Based on these recommendations, Horizon has prepared a Distribution System Plan ("DSP") that outlines the sustainment capital needed to maintain system performance over the next 20 years. The DSP will be submitted to the Ontario Energy Board ("OEB") in 2014 as part of Horizon's 2015 – 2019 rate application.

To support Horizon's rate application, KPMG was retained as an independent third-party, to complete an independent assurance review of the results contained in the Kinectrics report and provide a written opinion on the reasonableness of Kinectrics' findings and recommendations.

The procedures employed consisted solely of inquiry, observation, comparison and analysis of Horizon supplied information. The findings relied on the completeness and accuracy of the information as provided. KPMG expresses no opinion on financial results, internal control, data quality or other information.

KPMG recognizes this report may be called as evidence during the overall regulatory review process and as such KPMG may be needed to participate as an expert witness as prescribed by the OEB's procedural steps and timelines.



## 3 Assurance Review Scope

#### 3.1 Scope

As an independent third party, KPMG completed the required data analysis to assess whether the results contained in the Kinectrics report are reasonable and acceptable. KPMG reviewed the methodology and analyses used by Kinectrics to generate the asset health indices, the effective ages and the resulting "Flagged-for-Action" plans for each of the asset classes shown in Table 1 below.

#### Table 1: Asset Classes in Scope

#### Asset Class

Substation Transformers

Substation Circuit Breakers

Substation Switchgear

Pole Mounted Transformers

Overhead Conductors (in km) Primary

Overhead Conductors (in km) Secondary

Overhead Conductors (in km) Service

Overhead Line Switches

Wood Poles

Concrete Poles

Underground Cables (in km) Prim. XLPE

Underground Cables (in km) Prim. PILC

Underground Cables (in km) Sec. DB

Underground Cables (in km) Sec. ID

Underground Cables (in km) Serv. DB

Underground Cables (in km) Serv. ID

Pad Mounted Transformers

Pad Mounted Switchgear

Vault Transformers

**Utility Chambers** 

Vaults

Submersible LBD Switches



The following inquiry, observation, comparison and analysis were undertaken in the assurance review process:

- Compared the methodology used by Kinectrics to determine the probabilistic remaining asset life expectancy against current methodologies employed by leading practitioners of asset management and against known published standards
- Using the methodology described in the Kinectrics report, created independent calculation engines for health indices, effective age and Flagged-for-Action plans in order to recreate the results contained in the Kinectrics report
- Using standard unit costs provided by Horizon, monetized the respective Flagged-for-Action plans generated by Kinectrics and KPMG in order to test the materiality differences of the two plans
- Compared KPMG calculations against Kinectrics calculations in order to test the validity of the Kinectrics results
- Created an alternative Flagged-for-Action model using the published expected life data contained in the Asset Depreciation Study for the Ontario Energy Board ("OEB") (Kinectrics Inc. Report No: K-418033-RA-001-R000, 2010) in order to test the reasonableness of Kinectrics' results with accepted industry standards

#### 3.2 Not In Scope:

The following items were not in scope as part of the review process:

- Validation of the raw data quality (accuracy and completeness) used by Kinectrics to generate the results
- Validation of the selected failure curves used to estimate future asset failures
- Validation of actual asset conditions as expressed in the asset health indices
- Validation of the standard unit costs used in the determination of the Flagged-for-Action investment plans
- Interpretation of the Flagged-for-Action plans to future replacement or refurbishment investments



## 4 Assurance Review Methodology

The assurance review was conducted using data and information provided by Horizon and publically available information. These included:

- Horizon Utilities 2013 Asset Condition Assessment (Kinectrics Inc., 2013)
- Asset data including asset age, description, and asset condition for each of the asset classes
- Answers to KPMG's questionnaire requesting clarification or additional information
- Asset Depreciation Study for the Ontario Energy Board (Kinectrics Inc. Report No: K-418033-RA-001-R000, 2010)
- Answers obtained through interviews with Horizon representatives

The approach taken by KPMG to assess the Kinectrics results was to independently recreate the calculations using the data and information presented to KPMG by Horizon and the Kinectrics methodology contained in their report. The intermediate and final outcomes were compared to the published Kinectrics results. The comparisons that were completed included:

- Total population of individual asset classes
- Health indices for each asset class
- Effective ages for each asset class
- Flagged-for-Action profiles for each asset class
- Estimated 20 year monetary capital investment using Horizon supplied standard unit costs

In addition to comparing Kinectrics calculated results with KPMG's results, KPMG also conducted additional tests to confirm the reasonability of Kinectrics' recommendations. The additional tests included:

- Comparison of the calculated effective age distributions against the chronological age distributions for the different asset classes to determine reasonability of the methodology for determining effective age
- Comparison of estimated capital investment required for the Kinectrics' Flagged-for-Action plan and an alternative plan generated from the useful asset life ranges contained in the Depreciation Study for the Ontario Energy Board (Kinectrics Inc. Report No: K-418033-RA-001-R000, 2010)



## 5 Assurance Review Results

#### 5.1 Kinectrics Methodology

Kinectrics adopted a probabilistic approach to identify expected failures and probable number of units for replacement based on asset condition as represented by the asset health index score. The approach is non-deterministic (i.e. resultant actions are not linked to any specific assets but, rather applies to the asset group as a whole) for reactively replaced assets and deterministic (i.e. actions are directly linked to specific assets) for proactively replaced asset classes. Kinectrics' high-level methodology is shown in Figure 1 below.

Figure 1: Methodology for Determining Flagged-for-Action Plans



The formula used to calculate the health index for each asset class was unique depending on available asset condition data. The health index for each asset was calculated using weighted averages of known asset age and known asset condition parameters and their associated weighting factors. The health index was then used to determine the asset effective age as demonstrated in Figure 2 below using the appropriate survival curve determined jointly by Kinectrics and Horizon for that asset class.

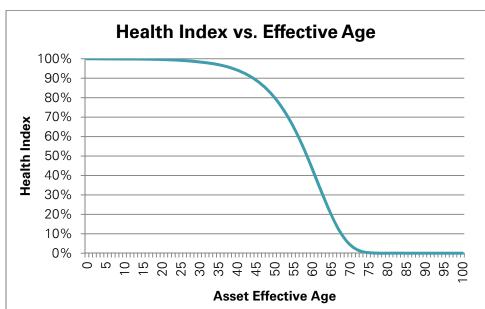


Figure 2: Determining Effective Age from Health Index



This method takes into account known asset condition in order to modify the actual chronological age into an effective age prior to calculating the probability of failure. For example, an asset that is well maintained would have an effective age that is lower than its actual chronological age indicating a lower probability of failure. Conversely, an asset that is overloaded or that is situated in adverse conditions would be de-rated to have a higher effective age as compared to its chronological age leading to a higher probability of failure. This method of predicting asset failure is a more representative method for predicting probability of failure over using only the chronological age.

Once the effective age distribution of an asset class is known, it is used to determine probable failure rates. For reactively replaced assets, the effective age distribution is mapped against the assigned failure rate curve for each asset class to determine the quantity of assets projected to fail over the next twenty years (see Figure 3 below).

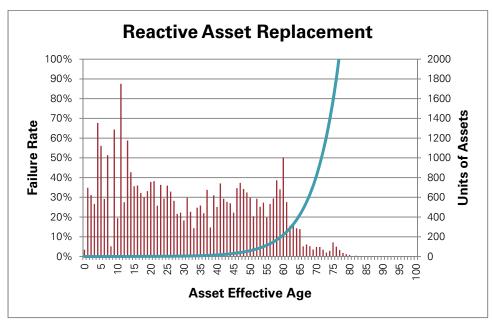


Figure 3: Flagged-for-Action Methodology used for Reactively Replaced Assets

For proactively replaced assets, the effective age is mapped against the cumulative probability of failure curve and assets with an effective age that returns a cumulative probability of failure of greater than or equal to 80% are flagged for replacement. Figure 4 represents the methodology used to flag proactively replaced assets.



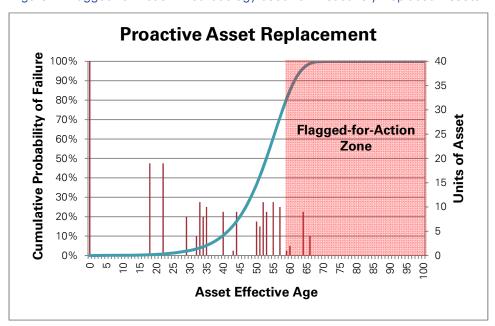


Figure 4: Flagged-for-Action Methodology used for Proactively Replaced Assets

The twenty year Flagged-for-Action plan is developed by progressively advancing the effective age of the assets yearly and any assets flagged for replacement are subtracted from the population and replaced with new assets for that year.

The probabilistic approach used by Kinectrics to calculate remaining asset life based on asset condition and asset age is consistent with similar models used in actuary science and by other utilities. The inclusion of asset condition in these calculations provides a more sophisticated approach than using just chronological age alone. Kinectrics also employed different predictive models for run to failure assets (reactively replaced) and for assets that are replaced or rehabilitated before failure occurs (proactively managed assets). This differentiation approach is more advanced than what is currently in use at most other utilities and in practice should provide more appropriate modelling of remaining asset life for reactively replaced assets and for proactively managed assets.

KPMG's assurance review of Kinectrics methodologies for calculating Flagged-for-Action plans for both reactively and proactively replaced asset classes confirmed that the respective methodologies were consistently applied across the asset classes. The selected methodology for estimating asset replacement for sustainment purposes is deemed to be reasonable and is an accepted practice within the utilities industry.

## 5.2 Kinectrics Analytics

The results of the assurance review on the analytics used to determine the Kinectrics results are shown in the following sections.

#### 5.2.1 Asset Populations Comparison

The total population of the individual asset classes were summed and compared to the population cited by Kinectrics in their report. Table 2 summarizes the results of the population comparison.



Table 2: Comparison of Asset Population

| Asset Class                           | KPMG Total<br>Asset<br>Population | Kinectrics<br>Total Asset<br>Population | Population<br>Difference | Percentage<br>Population<br>Difference |
|---------------------------------------|-----------------------------------|---|--------------------------|--|
| Substation Transformers               | 70                                | 70                                      | 0                        | 0.0%                                   |
| Substation Circuit Breakers           | 279                               | 279                                     | 0                        | 0.0%                                   |
| Substation Switchgear                 | 37                                | 37                                      | 0                        | 0.0%                                   |
| Pole Mounted Transformers             | 12886                             | 12886                                   | 0                        | 0.0%                                   |
| Overhead Conductors (in km) Primary   | 3386                              | 3386                                    | 0                        | 0.0%                                   |
| Overhead Conductors (in km) Secondary | 2196                              | 2196                                    | 0                        | 0.0%                                   |
| Overhead Conductors (in km) Service   | 1897                              | 1897                                    | 0                        | 0.0%                                   |
| Overhead Line Switches                | 711                               | 712                                     | -1                       | -0.1%                                  |
| Wood Poles                            | 42037                             | 42037                                   | 0                        | 0.0%                                   |
| Concrete Poles                        | 9761                              | 9761                                    | 0                        | 0.0%                                   |
| Underground Cables (in km) Prim. XLPE | 2060                              | 2060                                    | 0                        | 0.0%                                   |
| Underground Cables (in km) Prim. PILC | 1532                              | 1532                                    | 0                        | 0.0%                                   |
| Underground Cables (in km) Sec. DB    | 757                               | 757                                     | 0                        | 0.0%                                   |
| Underground Cables (in km) Sec. ID    | 533                               | 533                                     | 0                        | 0.0%                                   |
| Underground Cables (in km) Serv. DB   | 447                               | 447                                     | 0                        | 0.0%                                   |
| Underground Cables (in km) Serv. ID   | 588                               | 588                                     | 0                        | 0.0%                                   |
| Pad Mounted Transformers              | 5906                              | 5906                                    | 0                        | 0.0%                                   |
| Pad Mounted Switchgear                | 186                               | 186                                     | 0                        | 0.0%                                   |
| Vault Transformers                    | 4169                              | 4169                                    | 0                        | 0.0%                                   |
| Utility Chambers                      | 2075                              | 2075                                    | 0                        | 0.0%                                   |
| Vaults                                | 3413                              | 3413                                    | 0                        | 0.0%                                   |
| Submersible LBD Switches              | 117                               | 117                                     | 0                        | 0.0%                                   |

With one exception, the asset population in each asset class matches with Kinectrics' published results. The only difference observed is with the Overhead Line Switches where there is a 1 unit difference; however the overall impact to the analysis is immaterial. This comparison confirms that the data population is identical to the data population used by Kinectrics in their analysis.

#### 5.2.2 Health Indices and Effective Age Comparisons

Health index calculations were recreated independently by KPMG using Kinectrics' published methodology found in their report (KPMG was not privy to Kinectrics' proprietary calculation models). The calculated health indices were then used to determine the effective ages. When the calculated health indices were compared to Kinectrics results, there were no significant differences identified and the calculated values were then used to determine the effective ages for each asset class. The results of the effective ages are summarized in Figure 5 below.



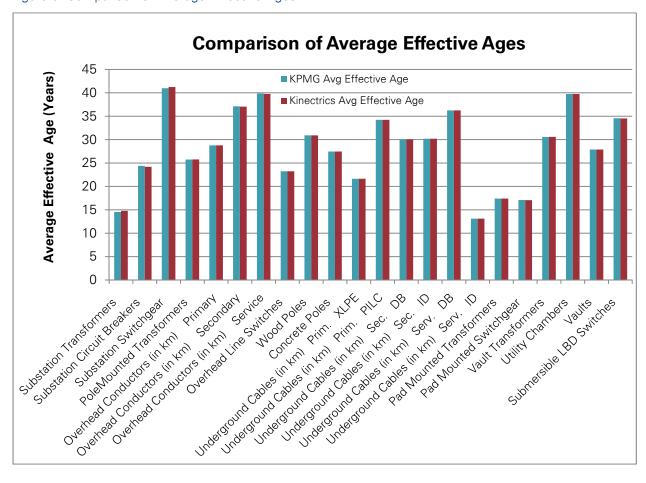


Figure 5: Comparison of Average Effective Ages

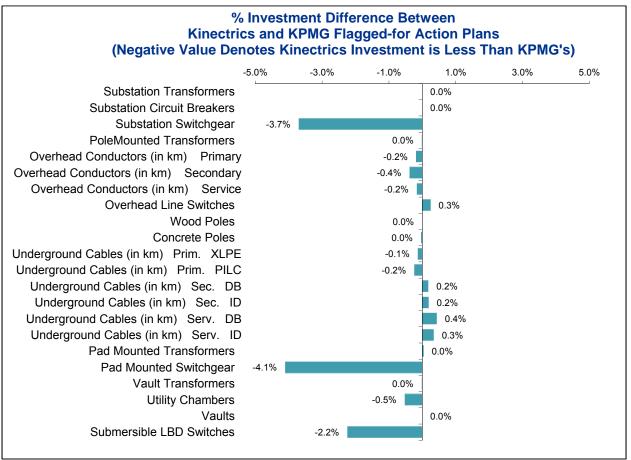
As evidenced by Figure 5, the average effective age distributions for the different asset classes are virtually identical for both Kinectrics calculations and KPMG's calculations. Minor differences were observed for the proactively replaced assets (Substation Transformers, Substation Circuit Breakers and Substation Switchgear) but as the subsequent Flagged-for-Action analysis shows, these minor differences did not result in material differences in the Flagged-for-Action plans for these asset classes.

#### 5.2.3 Flagged-for-Action Comparisons

Based on KPMG's calculated effective age distribution for each asset class, the Flagged-for-Action plans for the next twenty years were calculated based on whether the asset was deemed to be proactively replaced or reactively replaced. A detailed summary of the units Flagged-for-Action are shown in Appendix 1. The differences in the Flagged-for-Action plans are minor and are deemed to be immaterial. A summary of the percentage differences is shown in Figure 6, below.







The most significant percentage differences are in the Substation Switchgear, the Pad Mounted Switchgear and the Submersible LBD Switches asset classes. These asset classes have a small number of units in their population (less than 100 in each instance) and any small discrepancies in numeric values result in larger percentage differences when compared to other asset classes. The numerical differences can be found in Appendix 1. The impact of these differences to the Flagged-for-Action plan at the distribution network level over twenty years is immaterial.

Flagged-for-Action unit plans were monetized using standard unit costs in order to effectively allow comparison of the business impact of the identified differences. The standard unit costs used were provided by Horizon for each asset class. The resultant estimated investment over twenty years for the respective plans is shown in Figure 7 below.



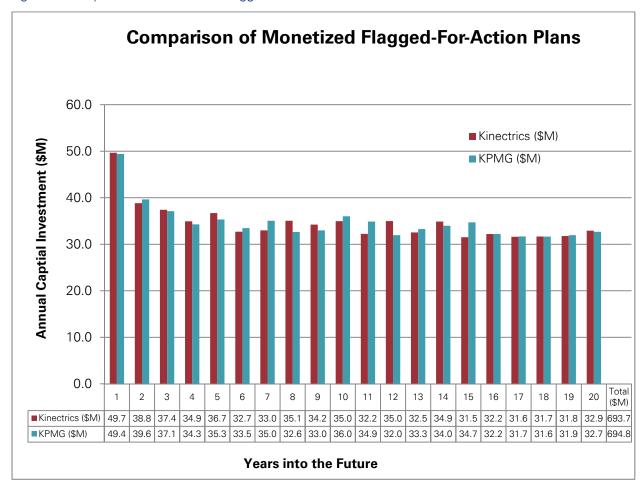


Figure 7: Comparison of Monetized Flagged-for-Action Plans

This monetized plan is meant to serve as a normalized comparison in dollar terms between the two respective Flagged-for-Action plans and it is not meant to be used as the definitive guide for Horizon's future capital investments. The two plans returned very similar total investment values over the twenty year span supporting the reasonableness of the calculations presented in the Kinectrics report. The total investment differs by only \$1.1 million over twenty years or 0.02% for the period. The estimated monetary differences for each asset class are summarized in Figure 8, below.

When comparing Kinectrics and KPMG's results for the first five years of the monetized investment plan, the total investment portfolio difference found during this time period was \$1.8 million or 0.09% of the five year plan. This investment difference was found to be primarily caused by the Substation Switchgear asset class. Due to the relatively low number of Substation Switchgear assets involved, the different values returned by the respective lookup methods employed by Kinectrics and KPMG resulted in slight variations in the timing of the Flagged-for-Action profile (See Appendix 1 for details). This variation was deemed to be insignificant to the overall five year Flagged-for-Action plan.



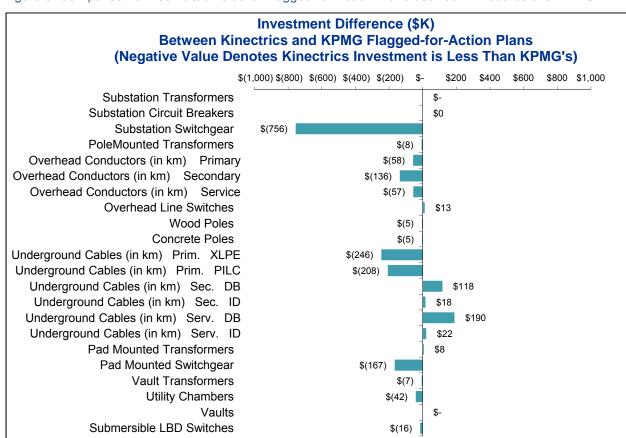


Figure 8: Comparison of Estimated Value of Flagged-for-Action Plans between Kinectrics and KPMG

The results of the analysis show that Kinectrics' resulting end calculations can be replicated independently within a very small margin of error. It is KPMG's opinion that Kinectrics has accurately applied their published methodology and formulas contained in their report against the Horizon supplied asset data set.

#### 5.3 Tests for Reasonableness

#### 5.3.1 Comparison of Effective Age against Chronological Age

In order to test whether the health indices and the associated effective ages of assets were reasonable, the calculated effective age was compared to the chronological age in terms of age distribution and overall average age for each of the asset classes. The age distribution comparison test was meant to reveal whether the incorporation of the asset condition parameters played a major role in altering the chronological age in a material way. Figure 9 below is an example of the comparison conducted for each asset class.



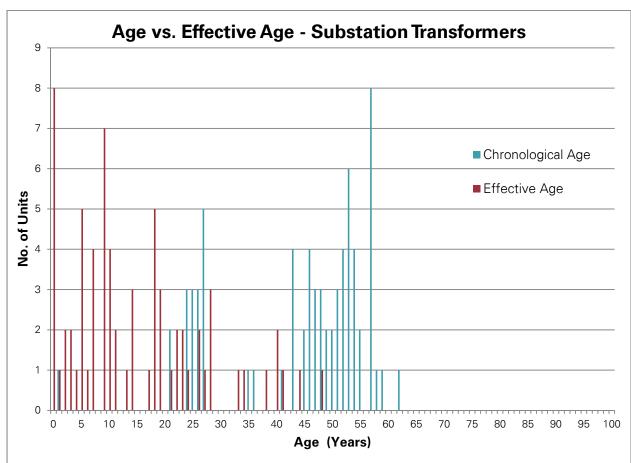


Figure 9: Example of Chronological Age versus Effective Age Comparison

The conversion of chronological age to effective age as a result of having asset condition parameters applied did shift the age distribution significantly for some asset classes. The differences between the average effective ages and the average chronological ages can be seen in Figure 10 below. The most significant shift is in the Substation Transformer asset class as the average effective age is significantly below the average chronological age. This phenomenon, as explained by Horizon representatives is the result of having significant maintenance and testing programs in place for this relatively old asset class to ensure their performance and reliability as these assets are key core components of the distribution system.

This test revealed that the use of effective ages to calculate the Flagged-for-Action plans would generate different end results than plans generated from chronological ages. However, the Flagged-for-Action differences in all the asset classes with the exception of the Substation Transformers would be reasonably close between the two different age profiles. For the Substation Transformers, the Flagged-for-Action plan using the assets' effective ages would significantly understate the number of units to be Flagged-for-Action when compared with a plan generated by the use of chronological age alone. Using effective ages to determine the Flagged-for-Action plan was deemed to be more reflective of actual asset conditions than using just chronological age.



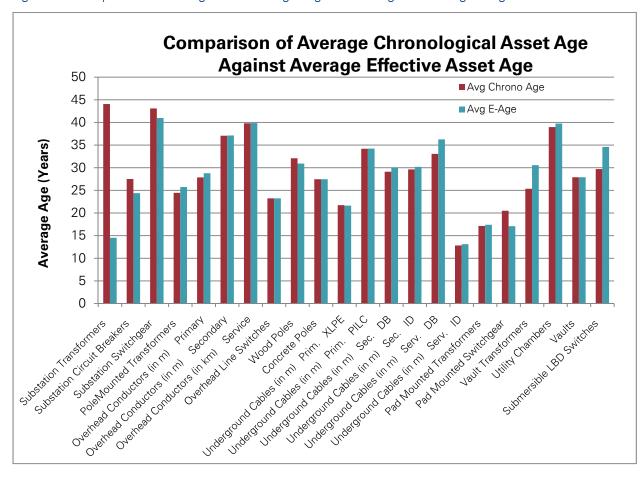


Figure 10: Comparison of Average Effective Ages against Average Chronological Ages

## 5.3.2 Comparison of Kinectrics' Flagged-for-Action Plan against Accepted Asset Life Standards

The final test to determine reasonability of the Kinectrics Flagged-for-Action plan was to compare the total plan against published and accepted industry standards for asset life expectancies. The standard life expectancies chosen for comparison were those published in the Asset Depreciation Study for the Ontario Energy Board (see Appendix 2). The published Typical Useful Life (TUL) and the Maximum Useful Life (MUL) were used to estimate the failure curve ( $f_t$ ) and the cumulative probability of failure ( $P_f$ ) for use in projecting asset replacements. Based on interpretation of the OEB report, the TUL was assigned 20%  $P_f$ , and the MUL was assigned 85%  $P_f$ . Failure curves were subsequently developed using the published TUL and MUL figures; the only exception was for the Submersible LBD Switches for which figures were not available in the OEB report. For this asset class, the UG Vault switch values for TUL and MUL were used as a proxy. Flagged-for-Action plans for each asset class were then calculated using the chronological age as the OEB useful lives data was developed for use with chronological asset age. The comparison of the normalized monetary results for the two different Flagged-for-Action plans is shown in Figure 11 below.



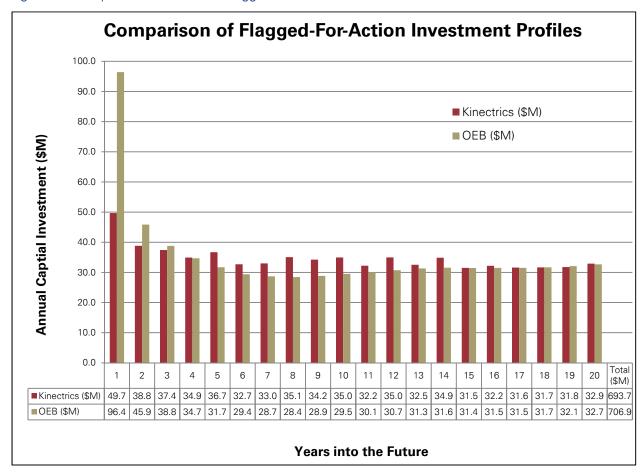


Figure 11: Comparison of Kinectrics Flagged-for-Action Plan versus Plan Generated from OEB Data

The total estimated investment for the two different plans over twenty years is within 2% of each other. The results calculated from the OEB life expectancies are heavily front-end loaded suggesting that model assesses Horizon's asset base as being closer to end of life than Kinectrics effective age model. This comparison substantiates the life curves used by Kinectrics in their models are reasonably close to industry accepted useful life data. The Kinectrics' life curves have longer average expected life-spans for some of the asset classes leading to fewer asset investments identified for the immediate short term. When compared to the OEB results, the Kinectrics Flagged-for-Action plan is not overstated and is reasonably within the industry accepted asset replacement or refurbishment practices for distribution utilities in Ontario.



## 6 Conclusions

Based on an independent assurance review of the methodology and analytics used in the Kinectrics report, it is KPMG's opinion that the approach used to arrive at the presented results is in line with industry practice and generally accepted methodologies. KPMG is of the opinion that the presented methodology has been appropriately and consistently applied against the Horizon supplied asset data in order to derive the final Flagged-for-Action plans for each of the asset classes. The interim and final results as presented in the Kinectrics report have been independently validated by KPMG to an acceptable margin of error for the intended purpose of projecting asset replacements or refurbishments over a twenty year period. When compared with accepted industry standards and practices for useful asset life, Kinectrics Flagged-for-Action plans appear to be reasonable and in line with industry expectations.



## Appendix 1 Comparison of Twenty Year Flagged-for-Action Plans

| Assets Class                          | Source     | 1    | 2    | 3    | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | Total |
|---------------------------------------|------------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Substation Transformers               | Kinectrics | 0    | 0    | 0    | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 1   | 0   | 1   | 0   | 2   | 5     |
| Substation Transformers               | KPMG       | 0    | 0    | 0    | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 1   | 0   | 0   | 1   | 2   | 5     |
| Substation Circuit Breakers           | Kinectrics | 16   | 0    | 10   | 0   | 11  | 0   | 9   | 0   | 17  | 0   | 7   | 0   | 0   | 0   | 0   | 9   | 1   | 0   | 0   | 9   | 89    |
| Substation Circuit Breakers           | KPMG       | 16   | 0    | 10   | 0   | 11  | 0   | 9   | 11  | 6   | 7   | 0   | 0   | 0   | 0   | 0   | 9   | 1   | 0   | 0   | 9   | 89    |
| Substation Switchgear                 | Kinectrics | 1    | 0    | 1    | 1   | 4   | 0   | 0   | 4   | 2   | 4   | 0   | 4   | 1   | 4   | 0   | 0   | 0   | 0   | 0   | 0   | 26    |
| Substation Switchgear                 | KPMG       | 0    | 1    | 1    | 0   | 2   | 1   | 3   | 0   | 1   | 5   | 4   | 0   | 2   | 3   | 4   | 0   | 0   | 0   | 0   | 0   | 27    |
| PoleMounted Transformers              | Kinectrics | 593  | 277  | 232  | 218 | 215 | 217 | 220 | 223 | 226 | 228 | 229 | 229 | 230 | 230 | 231 | 234 | 238 | 244 | 252 | 262 | 5028  |
| PoleMounted Transformers              | KPMG       | 594  | 277  | 232  | 218 | 215 | 217 | 220 | 223 | 226 | 228 | 229 | 229 | 230 | 230 | 232 | 234 | 238 | 244 | 252 | 262 | 5029  |
| Overhead Conductors (in km) Primary   | Kinectrics | 53   | 45   | 40   | 37  | 34  | 32  | 31  | 30  | 29  | 30  | 30  | 31  | 32  | 32  | 32  | 33  | 33  | 33  | 33  | 34  | 684   |
| Overhead Conductors (in km) Primary   | KPMG       | 53   | 46   | 41   | 37  | 34  | 32  | 31  | 30  | 29  | 30  | 30  | 31  | 32  | 32  | 33  | 33  | 33  | 33  | 33  | 34  | 685   |
| Overhead Conductors (in km) Secondary | Kinectrics | 86   | 63   | 52   | 44  | 40  | 38  | 38  | 38  | 39  | 39  | 39  | 39  | 39  | 39  | 38  | 37  | 36  | 34  | 33  | 32  | 843   |
| Overhead Conductors (in km) Secondary | KPMG       | 87   | 63   | 52   | 44  | 40  | 38  | 38  | 38  | 39  | 39  | 39  | 39  | 39  | 39  | 38  | 37  | 36  | 34  | 33  | 32  | 846   |
| Overhead Conductors (in km) Service   | Kinectrics | 97   | 69   | 54   | 44  | 39  | 36  | 35  | 36  | 36  | 36  | 36  | 36  | 36  | 35  | 34  | 33  | 32  | 30  | 28  | 27  | 809   |
| Overhead Conductors (in km) Service   | KPMG       | 99   | 69   | 54   | 44  | 39  | 36  | 35  | 36  | 36  | 36  | 36  | 36  | 36  | 35  | 34  | 33  | 31  | 30  | 28  | 27  | 810   |
| Overhead Line Switches                | Kinectrics | 31   | 26   | 23   | 22  | 20  | 20  | 19  | 18  | 19  | 18  | 18  | 18  | 17  | 17  | 17  | 17  | 16  | 17  | 17  | 17  | 387   |
| Overhead Line Switches                | KPMG       | 31   | 26   | 23   | 22  | 21  | 20  | 19  | 19  | 18  | 18  | 18  | 17  | 17  | 17  | 17  | 17  | 17  | 17  | 17  | 17  | 386   |
| Wood Poles                            | Kinectrics | 1509 | 1103 | 1011 | 967 | 935 | 905 | 876 | 845 | 814 | 782 | 752 | 724 | 699 | 678 | 662 | 648 | 637 | 627 | 619 | 611 | 16404 |
| Wood Poles                            | KPMG       | 1509 | 1103 | 1011 | 968 | 935 | 906 | 876 | 845 | 814 | 782 | 752 | 724 | 699 | 678 | 661 | 648 | 637 | 627 | 619 | 611 | 16405 |
| Concrete Poles                        | Kinectrics | 97   | 98   | 100  | 101 | 103 | 104 | 105 | 107 | 108 | 109 | 110 | 111 | 112 | 114 | 115 | 118 | 119 | 121 | 123 | 126 | 2201  |
| Concrete Poles                        | KPMG       | 97   | 98   | 100  | 101 | 103 | 104 | 105 | 106 | 108 | 109 | 110 | 111 | 112 | 114 | 116 | 117 | 119 | 121 | 124 | 126 | 2202  |
| Underground Cables (in km) Prim. XLPE | Kinectrics | 126  | 103  | 96   | 91  | 88  | 85  | 83  | 80  | 78  | 76  | 74  | 72  | 71  | 70  | 69  | 68  | 67  | 66  | 66  | 66  | 1595  |
| Underground Cables (in km) Prim. XLPE | KPMG       | 127  | 103  | 95   | 91  | 88  | 85  | 83  | 80  | 78  | 76  | 74  | 73  | 71  | 70  | 69  | 68  | 67  | 67  | 66  | 66  | 1597  |
| Underground Cables (in km) Prim. PILC | Kinectrics | 11   | 11   | 12   | 12  | 12  | 13  | 14  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 20  | 21  | 22  | 23  | 24  | 25  | 339   |
| Underground Cables (in km) Prim. PILC | KPMG       | 12   | 12   | 12   | 12  | 12  | 13  | 14  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 20  | 21  | 22  | 23  | 24  | 25  | 340   |
| Underground Cables (in km) Sec. DB    | Kinectrics | 28   | 28   | 28   | 27  | 27  | 27  | 27  | 27  | 26  | 26  | 26  | 26  | 25  | 25  | 25  | 25  | 24  | 24  | 24  | 24  | 519   |
| Underground Cables (in km) Sec. DB    | KPMG       | 28   | 28   | 28   | 27  | 27  | 27  | 27  | 27  | 26  | 26  | 26  | 26  | 25  | 25  | 25  | 25  | 24  | 24  | 24  | 24  | 518   |
| Underground Cables (in km) Sec. ID    | Kinectrics | 21   | 21   | 21   | 20  | 20  | 19  | 19  | 19  | 18  | 18  | 18  | 18  | 17  | 17  | 17  | 17  | 17  | 16  | 16  | 16  | 365   |
| Underground Cables (in km) Sec. ID    | KPMG       | 21   | 21   | 20   | 20  | 20  | 19  | 19  | 19  | 18  | 18  | 18  | 18  | 17  | 17  | 17  | 17  | 16  | 16  | 16  | 16  | 364   |
| Underground Cables (in km) Serv. DB   | Kinectrics | 20   | 20   | 20   | 19  | 19  | 19  | 19  | 18  | 18  | 18  | 18  | 17  | 17  | 17  | 16  | 16  | 16  | 15  | 15  | 15  | 352   |
| Underground Cables (in km) Serv. DB   | KPMG       | 20   | 20   | 20   | 19  | 19  | 19  | 19  | 18  | 18  | 18  | 18  | 17  | 17  | 17  | 16  | 16  | 16  | 15  | 15  | 15  | 350   |
| Underground Cables (in km) Serv. ID   | Kinectrics | 10   | 11   | 11   | 11  | 11  | 12  | 12  | 12  | 13  | 13  | 13  | 13  | 14  | 14  | 14  | 14  | 14  | 15  | 15  | 15  | 257   |
| Underground Cables (in km) Serv. ID   | KPMG       | 10   | 11   | 11   | 11  | 11  | 12  | 12  | 12  | 12  | 13  | 13  | 13  | 13  | 14  | 14  | 14  | 14  | 15  | 15  | 15  | 256   |
| Pad Mounted Transformers              | Kinectrics | 17   | 17   | 20   | 23  | 27  | 31  | 36  | 41  | 47  | 53  | 59  | 65  | 70  | 75  | 79  | 83  | 87  | 92  | 98  | 105 | 1125  |
| Pad Mounted Transformers              | KPMG       | 17   | 17   | 20   | 23  | 27  | 31  | 36  | 41  | 47  | 53  | 59  | 65  | 70  | 75  | 79  | 83  | 87  | 92  | 98  | 105 | 1125  |
| Pad Mounted Switchgear                | Kinectrics | 3    | 3    | 3    | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 5   | 70    |
| Pad Mounted Switchgear                | KPMG       | 3    | 3    | 3    | 3   | 3   | 3   | 3   | 3   | 3   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 5   | 5   | 73    |
| Vault Transformers                    | Kinectrics | 309  | 294  | 282  | 270 | 260 | 250 | 240 | 230 | 221 | 212 | 203 | 194 | 186 | 178 | 170 | 162 | 156 | 150 | 144 | 139 | 4250  |
| Vault Transformers                    | KPMG       | 309  | 294  | 282  | 270 | 260 | 250 | 240 | 230 | 221 | 212 | 203 | 194 | 186 | 178 | 170 | 163 | 156 | 150 | 144 | 139 | 4251  |
| Utility Chambers                      | Kinectrics | 12   | 13   | 13   | 14  | 15  | 15  | 16  | 17  | 17  | 18  | 19  | 20  | 20  | 21  | 22  | 23  | 23  | 24  | 25  | 26  | 373   |
| Utility Chambers                      | KPMG       | 13   | 13   | 13   | 14  | 15  | 15  | 16  | 17  | 17  | 18  | 19  | 20  | 20  | 21  | 22  | 23  | 24  | 24  | 25  | 26  | 375   |
| Vaults                                | Kinectrics | 6    | 7    | 7    | 7   | 8   | 8   | 9   | 10  | 10  | 11  | 12  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 239   |
| Vaults                                | KPMG       | 6    | 7    | 7    | 7   | 8   | 8   | 9   | 10  | 10  | 11  | 12  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 239   |
| Submersible LBD Switches              | Kinectrics | 14   | 8    | 7    | 6   | 5   | 5   | 5   | 4   | 4   | 4   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 3   | 87    |
| Submersible LBD Switches              | KPMG       | 14   | 8    | 7    | 6   | 5   | 5   | 5   | 4   | 4   | 4   | 4   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 89    |



## Appendix 2 Summary of OEB's Asset Useful Lives

Asset Depreciation Study for the Ontario Energy Board F - SUMMARY OF RESULTS

#### F SUMMARY OF RESULTS

Table F - 1 summarizes useful lives, and factors impacting those lives as developed by this report.

Table Fi-1 Summary of Componentized Assets, Service Life and Factors

|            |    | ASSET DETAILS                  |                    |       |           | USEFUL LIFE |           |    |    | FACTORS ** |    |    |     |  |  |  |
|------------|----|--------------------------------|--------------------|-------|-----------|-------------|-----------|----|----|------------|----|----|-----|--|--|--|
| PARENT*    | #  | <br>  Category  Compor         | nent   Type        |       | MIN<br>UL | TUL         | MAX<br>UL | мс | EL | EN         | ОР | МР | NPF |  |  |  |
|            |    |                                | Overall            |       | 35        | 45          | 75        |    |    |            |    |    |     |  |  |  |
|            | 1  | Fully Dressed Wood Poles       |                    | Wood  | 20        | 40          | 55        | н  | L  | м          | NI | L  | L   |  |  |  |
|            |    |                                | Cross Arm          | Steel | 30        | 70          | 95        |    |    |            |    |    |     |  |  |  |
|            |    |                                | Overall            |       | 50        | 60          | 80        |    |    |            |    |    |     |  |  |  |
|            | 2  | Fully Dressed Concrete Poles   | Cross Arm          | Wood  | 20        | 40          | 55        | н  | L  | м          | NI | L  | NI  |  |  |  |
|            |    |                                | CIOSS ATTII        | Steel | 30        | 70          | 95        |    |    |            |    |    |     |  |  |  |
|            |    |                                | Overall            |       | 60        | 60          | 80        |    |    |            |    |    |     |  |  |  |
|            | 3  | Fully Dressed Stee   Poles     | Cmss 4sm           | Wood  | 20        | 40          | 55        | н  | М  | L          | NI | L  | NI  |  |  |  |
| он         |    |                                | Cross Arm          | Steel | 30        | 70          | 95        |    |    |            |    |    |     |  |  |  |
|            | 4  | OH Line Switch                 |                    |       |           | 45          | 55        | L  | L  | L          | L  | М  | L   |  |  |  |
|            | 5  | OH Line Switch Motor           |                    | 15    | 25        | 25          | L         | NI | L  | L          | М  | L  |     |  |  |  |
|            | 6  | OH Line Switch RTU             |                    | 15    | 20        | 20          | NI        | NI | L  | L          | L  | М  |     |  |  |  |
|            | 7  | OH Integral Switches           |                    | 35    | 45        | 60          | L         | М  | М  | М          | L  | Н  |     |  |  |  |
|            | 8  | OH Conductors                  |                    | 50    | 60        | 75          | М         | L  | М  | NI         | NI | L  |     |  |  |  |
|            | 9  | OH Transformers & Voltage Regi |                    | 30    | 40        | 60          | L         | М  | М  | NI         | NI | М  |     |  |  |  |
|            | 10 | OH Shunt Capacitor Banks       |                    | 25    | 30        | 40          | -         |    | -  | -          | -  |    |     |  |  |  |
|            | 11 | Reclosers                      |                    | 25    | 40        | 55          | L         | L  | L  | М          | L  | M  |     |  |  |  |
|            |    |                                | Overall<br>Bushing |       | 30        | 45          | 60        |    |    |            |    | L  |     |  |  |  |
|            | 12 | Power Transformers             |                    |       | 10        | 20          | 30        | NI | М  | М          | L  |    | NI  |  |  |  |
|            |    |                                | Tap Changer        |       | 20        | 30          | 60        |    |    |            |    |    |     |  |  |  |
|            | 13 | Station Service Transformer    |                    |       | 30        | 45          | 55        | NI | L  | М          | L  | NI | L   |  |  |  |
|            | 14 | Station Grounding Transformer  |                    |       | 30        | 40          | 40        | -  | -  | -          | -  | -  |     |  |  |  |
| TS & MS    |    |                                | Overall            |       | 10        | 20          | 30        |    |    |            |    |    |     |  |  |  |
| 13 13 1013 | 15 | Station DC System              | Battery bank       |       | 10        | 15          | 15        | NI | М  | L          | L  | м  | м   |  |  |  |
|            |    |                                | Charger            |       | 20        | 20          | 30        |    |    |            |    |    |     |  |  |  |
|            | 16 | Station Metal Clad Switchgear  | Overall            |       | 30        | 40          | 60        | L  | L  | м          | м  | м  | м   |  |  |  |
|            |    |                                | Removable Breaker  |       | 25        | 40          | 60        |    | Ō  |            |    |    | 141 |  |  |  |
|            | 17 | Station Independent Breakers   |                    |       | 35        | 45          | 65        | м  | М  | М          | М  | М  | М   |  |  |  |
|            | 18 | Station Switch                 |                    |       | 30        | 50          | 60        | М  | L  | М          | М  | М  | L   |  |  |  |

<sup>\*</sup> OH = Overhead Lines System TS & MS = Transformer and Municipal Stations

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MC = Mechanical Stress EL = Electrical Loading OP = Operating Practices EN = Environmental Conditions
 MP = Maintenance Practices NPF=Non-Physical Factors
 H=High M=Medium L=Low NI=No Impact

Asset Depreciation Study for the Ontario Energy Board

#### F-SUMMARY OF RESULTS

|         |    | ASSET DETAILS  |                     |           | USEFUL II FE |           |     |     | FACTORS ** |     |     |      |  |  |  |
|---------|----|--|---------------------|-----------|--------------|-----------|-----|-----|------------|-----|-----|------|--|--|--|
| PARENT* | #  | Category  Compor   | nent   Type         | MIN<br>UL | TUL          | MAX<br>UL | мс  | EL  | ΕN         | ОР  | МР  | NPF  |  |  |  |
|         | 19 | Electromechanical Relays   |                     | 25        | 35           | 50        | NI  | NI  | NI         | NI  | NI  | н    |  |  |  |
|         | 20 | Solid State Relays   |                     | 10        | 30           | 45        | NI  | NI  | NI         | NI  | NI  | н    |  |  |  |
| TS & MS | 21 | Digital & Numeric Relays   |                     | 15        | 20           | 20        | NI  | NI  | NI         | NI  | NI  | н    |  |  |  |
|         | 22 | Rigid Busbars  |                     | 30        | 55           | 60        | L   | L   | L          | NI  | NI  | L    |  |  |  |
|         | 23 | Steel Structure  |                     | 35        | 50           | 90        | L   | NI  | М          | NI  | NI  | L    |  |  |  |
|         | 24 | Primary Paper Insulated Lead Co                                    | wered (PILC) Cables | 60        | 65           | 75        | L   | L   | М          | L   | NI  | М    |  |  |  |
|         | 25 | Primary Ethylene-Propylene Rub                                     | ber (EPR) Cables    | 20        | 25           | 25        | NI  | М   | L          | NI  | NI  | NI   |  |  |  |
|         | 26 | Primary Non-Tree Retardant (TR<br>Polyethylene (XLPE) Cables Direc | 20                  | 25        | 30           | М         | М   | М   | L          | L   | L   |      |  |  |  |
|         | 27 | Primary Non-TR XLPE Cables In C                                    | 20                  | 25        | 30           | М         | М   | М   | L          | L   | М   |      |  |  |  |
|         | 28 | Primary TR XLPE Cables Direct Bi                                   | 25                  | 30        | 35           | М         | М   | М   | L          | L   | L   |      |  |  |  |
|         | 29 | Primary TR XLPE Cables In Duct                                     | 35                  | 40        | 55           | М         | М   | М   | L          | L   | L   |      |  |  |  |
|         | 30 | Secondary PILC Cables  | 70                  | 75        | 80           | NI        | L   | L   | NI         | NI  | Н   |      |  |  |  |
|         | 31 | Secondary Cables Direct Buried                                     | 25                  | 35        | 40           | М         | М   | М   | L          | NI  | NI  |      |  |  |  |
|         | 32 | Secondary Cables In Duct   | 35                  | 40        | 60           | М         | М   | М   | L          | NI  | NI  |      |  |  |  |
|         | 33 | Network Transformers   | Overall             | 20        | 35           | 50        | NI  | L   | н          | NI  | NI  | NI   |  |  |  |
| UG      | 33 | Network Hanslorners  | Protector           | 20        | 35           | 40        | IVI | '   |            | 141 | IVI | I WI |  |  |  |
|         | 34 | Pad-Mounted Transformers   | 25                  | 40        | 45           | L         | М   | М   | NI         | L   | L   |      |  |  |  |
|         | 35 | Submersible/Vault Transformers                                     | ı                   | 25        | 35           | 45        | L   | М   | М          | NI  | L   | L    |  |  |  |
|         | 36 | UG Foundations   |                     | 35        | 55           | 70        | Μ   | NI  | М          | ٦   | ٦   | М    |  |  |  |
|         | 37 | UG Vaults  | Overall             | 40        | 60           | 80        | м   | NI  | м          | L   | L   | ı    |  |  |  |
|         | 21 | OG VOUIS   | Roof                | 20        | 30           | 45        | 101 | IVI | 101        |     |     |      |  |  |  |
|         | 38 | UG Vault Switches  | 20                  | 35        | 50           | ٦         | ٦   | L   | ٦          | ٦   | NI  |      |  |  |  |
|         | 39 | Pad-Mounted Switchgear   |                     | 20        | 30           | 45        | L   | L   | Н          | L   | L   | L    |  |  |  |
|         | 40 | Ducts  |                     | 30        | 50           | 85        | н   | NI  | М          | NI  | NI  | L    |  |  |  |
|         | 41 | Concrete Encased Duct Banks  |                     | 35        | 55           | 80        | М   | NI  | М          | NI  | NI  | L    |  |  |  |
|         | 42 | Cable Chambers   |                     | 50        | 60           | 80        | М   | NI  | Н          | NI  | L   | NI   |  |  |  |
| s       | 43 | Remote SCADA   |                     | 15        | 20           | 30        | NI  | NI  | L          | N   | ٦   | Н    |  |  |  |

H=High M=Medium L=Low NI=No Impact

KINECTRICS INC -18 - K-418033-RA-001-R000



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## **Author Biography**

#### Julius Pataky, P.Eng. MBA

Julius Pataky is a KPMG Partner with 35 years progressive industry and consulting experience in the energy industry, with demonstrated leadership skills in asset management, building effective teams, leading transformation and bringing innovation to the business. Julius joined KPMG after having led innovative asset management solutions at BC Transmission and BC Hydro. In his roles as VP, Asset Investment, he brought the PAS 55 framework into organization's operating model, led the development of innovative asset analytic and planning solutions and gained regulatory approval for increased capital investment. He not only had accountability for developing the Capital Plans for transmission and distribution but also developing the regulatory justification for these capital investments. During this period, investments in the grid for the utility had grown from under \$200M/yr to \$1.3B/yr. He acted as company lead in communication of the need for increase in grid investment with stakeholders and the public. He also led numerous consultation efforts to gain acceptance of contentious projects with municipal leaders and landowners.

#### David Cheng, P.Eng.

David Cheng is a Senior Manager in KPMG LLP's Advisory Services Practice and is a member of the firm's Asset Management practice. Over his career, David has successfully transformed numerous businesses through his knowledge of asset management, operations management, business process improvement, information management and project and program management. He has led a diverse portfolio of projects as a consultant for private and public sector organizations plus he has years of executive and managerial experience leading teams in the utilities, aerospace, high-technology, healthcare and consumer products industries. As a former Manager of Asset Data and Information at BC Hydro and BC Transmission Corporation (BCTC), David was responsible for the development of asset analytic algorithms used to support capital investment justifications contained within the rate application submissions to BC Utilities Commission (BCUC). The asset analytics deployed probabilistic asset health based analysis to determine projected asset replacement requirements based on asset condition and asset demographics.





## **David Cheng**

#### Senior Manager, Advisory Services, Management Consulting

KPMG LLP Suite 600 - 750 West Pender St. Vancouver, BC Canada V6C 2T7 Tel: 604-673-4452 dcheng1@kpmg.ca

#### **Function and Specialization**

- Asset Management
- Data and Information Management
- Business Process Improvement
- Utilities

#### Education, Licenses & Certifications

- Bachelor of Applied Science The University of British Columbia
- P.Eng.
   The Professional and Geoscientist Association of BC

#### **Background**

David Cheng is a Senior Manager in KPMG LLP's Advisory Services Practice in Vancouver Canada and is a member of the firm's Asset Management practice. Over his career, David has successfully transformed numerous businesses through his knowledge of asset management, operations and engineering management, business process improvement, information management and project and program management. He has led a diverse portfolio of projects as a consultant for private and public sector organizations plus he has years of executive and managerial experience leading teams in the utilities, aerospace, high-technology, healthcare and consumer products industries.

#### **Relevant Experience**

- Integrated Asset Management Capital Planning Process, Major Utility David was a key member of a team responsible for developing the integrating planning process for a major electric utility in Western Canada. The integrated planning process included the identification of needs, integrated solution options assessment, consolidated project planning, project prioritization and project approval. As part of this project, David was responsible for leading the development of the functional specifications for a Needs Registry built on a geospatial web mapping engine.
- Asset Management Data and Information Management, Major Utility –
  David led a team that delivered the Data and Information Management function
  for Asset Management within a major integrated electric utility. In his role, he
  directed the development of a five-year strategic roadmap for the major utility's
  asset management related data and information needs. The roadmap took into
  consideration the business requirements for asset condition and investment
  analytics, geospatial visualization and analysis, emerging data standards and
  available commercial off-the-shelf products to replace custom developed
  applications.
- Retail Electricity Billing and Meter Data Management Policy: Government
  of Alberta On behalf of the government of Alberta, managed the development
  of the billing and meter data management policies during the deregulation of the
  electric industry in Alberta. The work included the facilitated negotiations
  between stakeholders in the wholesale and retail environments on their roles
  and responsibilities for billing and meter data management and the subsequent
  development of approved policies and standards for billing and meter data
  management.
- Capital Asset Acquire to Retire Business Case, Major Utility David successfully led a project that delivered a business case and an information technology investment roadmap for a large western Canadian utility. The project involved the assessment of business requirements within the capital management process, evaluation of existing technologies in use and potential solutions that are currently available in the market. Final recommendations were presented to company executives for review and budget approval.

## **David Cheng**

#### Senior Manager, Advisory Services, Management Consulting

KPMG LLP Suite 600 - 750 West Pender St. Vancouver, BC Canada V6C 2T7 Tel: 604-673-4452 dcheng1@kpmg.ca

#### **Instructions to Expert**

KPMG was retained by Horizon as a third party to conduct an independent assurance review and provide an opinion on Kinectrics' methodology and the resultant findings and recommendations contained in their report. KPMG provided advisory services that consisted of inquiry, observation, analysis and comparison of Horizon-provided information. The findings relied on the completeness and accuracy of the information provided. KPMG expresses no opinion on financial results, internal control, data quality or other information.

#### Specific Information upon which Expert's Evidence is Based

The following sources of information were consulted:

- Kinectrics Inc. (2013). Horizon Utilities 2013 Asset Condition Assessment. Toronto: Kinectrics Inc.
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#### Contact us

#### **Mary Hemmingsen**

Partner, National Sector Leader for Power and Utilities

**T** +1 416 777 8896

E mhemmingsen@kpmg.ca

#### **Julius Pataky**

Partner, Advisory Services

**T** +1 604 691 3333 **E** jpataky@kpmg.ca

#### **David Cheng**

Senior Manager, Advisory Services

**T** +1 604 673 4452 **E** dcheng1@kpmg.ca

#### kpmg.ca

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## <u>Appendix D – Innovative Customer Consultation Report</u>



**Innovative Research Group, Inc.** 

Toronto • Calgary • Vancouver

# Customer Consultation Report Distribution System Plan Review

April 2014

Prepared for:

Horizon Utilities Corporation Regulatory Department 55 John Street North Hamilton, ON, L8R 3M8



## **Customer Consultation Report Distribution System Plan Review**

April 2014

This report has been prepared by Innovative Research Group Inc. (INNOVATIVE) for Horizon Utilities Corporation.

The conclusions drawn and opinions expressed are those of the authors.

#### **Innovative Research Group Inc.**

56 The Esplanade, Suite 310 Toronto ON | M5E 1A7 Tel: 416.642.6340

Fax: 416.640.5988

www.innovativeresearch.ca

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## Introduction

#### **About this Consultation**

Horizon Utilities is filing its next Cost of Service application with the Ontario Energy Board (OEB) in the spring of 2014. The outcome of this application will determine Horizon Utilities' electricity distribution rates for a five year term beginning January 1, 2015 through to December 31, 2019.

As part of the application, Horizon Utilities is proposing a Distribution System Plan (DSP) that the organization believes will maintain the current distribution system and where appropriate, renew or expand the infrastructure to meet challenges over the long term. The plan is designed to strike a balance between managing customer rate impacts and meeting the required investment needs.

A key requirement of the rate application process includes active engagement between Horizon Utilities and their customers. The OEB expects distributors to provide an overview of customer engagement activities that the distributor has undertaken with respect to its plans and how customer needs have been reflected in the distributor's application.

To assist with their rate filing application, Horizon Utilities commissioned Innovative Research Group Inc. (INNOVATIVE) to act as an independent consultant to help design, collect feedback and document their customer engagement and consultation process.

The protection of consumer interests and the promotion of economic efficiency and cost effectiveness within a financially viable industry are the foundation of the *Renewed Regulatory Framework for Electricity (RRFE)*. These objectives are the main principles of the distribution rate-setting and performance measurement policies.

The OEB's new "consumer-centric" approach to rate applications contained in the RRFE, requires LDCs to demonstrate services are provided in a manner that responds to identified customer preferences. Identifying and reacting to customer preferences as it pertains to DSP development is new to Ontario's LDCs and has never before been done in Canada. INNOVATIVE is excited to have been selected to assist Horizon Utilities in one of the first filings under the new rate applications process. Running a consultation on a DSP has one key challenge – the lack of awareness of the distribution system, how it is funded, and the nature of its challenges. There were three key steps in this process.

- The first step was to review the DSP to identify potential questions that would allow customers
  to share their needs and preferences and then to develop a workbook that would provide the
  information needed to allow customers with different levels of initial knowledge to answer
  those questions.
- The second step was to conduct the more qualitative elements of the process. Qualitative in research refers to processes that identify the range of views on a topic. This included the online workbook, the discussion groups and the one-on-ones with key customers.
- The third step was quantitative. Quantitative in research refers to processes that allow us to draw generalizable conclusions and relies on the use of random sample surveys, in this case surveys based on the feedback from the qualitative research.

The fact that each individual consultation element ended up with the same basic findings reinforces the validity of those findings.

While most customers felt this approach to engagement was effective at soliciting their feedback on Horizon Utilities' 5-Year Distribution System Plan, other ideas on how to improve upon the process were collected throughout the consultation. This is discussed in detail in body of the report.

# **Executive Summary**

The goal of this consultation effort is to identify the needs and preferences of Horizon Utilities' customers on the key issues in its DSP. INNOVATIVE is excited to have the opportunity to work with Horizon Utilities on one of the first DSP consultations under the new OEB Filing Requirements for DSPs (Chapter 5 of the OEB's Filing Requirements for Distribution Rate Applications). While there are many ways to meet the OEB's requirement, we feel the combination of open input through an online workbook, one-on-one interviews with Key Accounts<sup>1</sup>, facilitated discussion groups with community stakeholders and the engagement of randomly selected customers through discussion groups and a telephone survey has ensured all customer segments have had a good opportunity to express their needs and preferences.

#### Majority of Customers Give Permission to Proceed

Overall, a majority of customers – in all rate classes – gave Horizon Utilities "permission" for their proposed rate change as it pertains to the bill impact and pacing of their capital investment plan.

In the context of this report, customer "permission" is defined as those customers who either believe the proposed rate increase is reasonable and [they] support it or have expressed the view that they don't like it, but [they] think the proposed rate increase is necessary given the information presented by Horizon Utilities.

The "I don't like it but I think the proposed rate increase is necessary" category provides a response for the many Horizon customers who feel conflicted about the plan. Many people struggle with increasing electricity bills. For instance, two thirds (66%) of the residential telephone survey respondents agree "the cost of my electricity bill has a major impact on my finances and requires I do without some other important priorities." When asked what Horizon Utilities could do better, many asked for lower rates. However, 76% agree with the proposition that "we should invest in our electricity system infrastructure now or we will end up paying more". Relatively few residential customers are prepared to reduce reliability to limit rate increases.

In the end, a big part of the permission given to Horizon Utilities was based on trust. Customers noted that their feedback was largely based on information provided by Horizon Utilities. As such, a number of customers raised the following questions:

- Is the presented information accurate?
- Is Horizon Utilities exaggerating the urgency and need for equipment renewal?

<sup>&</sup>lt;sup>1</sup> Major customers with an average monthly peak demand of at least 5 MW.

• What do opponents of this proposed plan have to say about it?

Concerns about the information presented were largely offset by an explanation of the rate application process. Customers were pleased to learn that OEB officials and intervenors would have an opportunity to review and challenge all the information presented by Horizon Utilities.

It is also important to note that the same basic findings are observed among customers who were highly energy literate and those who were not, as well as finding similar results from the workbook-based discussion and the telephone survey, which provided much less information to respondents than the workbook engagement processes did.

Finally, readers of this report will find the same basic results on all the topics in the consultation across each of the different means of engagement with all of the different customer groups. If the basic facts hold up in the OEB process, INNOVATIVE is confident that consumers will, with some reluctance, accept a price increase.

#### Phase 1: Customer Online Workbook

The online workbook was available for Horizon Utilities' customers to access for 34 days, between December 11, 2013 and January 13, 2014. To ensure customer privacy, answers were grouped together with those of others who completed the same question and the information provided was used for statistical purposes only.

Valid responses to the online workbook are as follows:

- 1,049 unique visitors came to the online workbook's landing page.
- 333 unique visitors continued beyond the landing page.
- 151 customers completed at least the profiling section of the online workbook (140 residential/11 business customers).
- 111 customers completed the entire online workbook by answering all questions (103 residential/8 business customers).

The results are based on completed answers to the online workbook questions by residential customers, ranging from 140 to 103 responses.

#### Residential customer permission on Horizon Utilities' proposed rate increase:

More than 6-in-10 (62%) respondents give Horizon Utilities permission to increase residential rates by the proposed amount; with 20% saying they support the proposed rate increase and 42% saying they think it is necessary. On the contrary, 32% of residential respondents are opposed to the rate increase, while 6% don't know or don't have an opinion either way. The main reasons provided for permission were that paying now avoids rising costs later and that the rate increase is fair.

| Q: Based on what you know and have heard today about Horizon Utilities'  |     |
|--|-----|
| plan, which of the following best represents your point of view? [n=103] |     |
| The proposed rate increase is reasonable and I support it                | 20% |
| I don't like it, but I think the proposed rate increase is necessary     | 42% |
| The proposed rate increase is unreasonable and I oppose it               | 32% |
| Don't know   | 6%  |

#### Phase 2: DSP Workbook-based Facilitated Discussion

The consultation sessions were held in St. Catharines on January 14, 2014 and in Hamilton on January 15, 2014. A total of 43 stakeholders and general service customers participated in these consultation sessions.

#### St. Catharines: January 14, 2014

| Community and Industry Stakeholders    | 5 participants |
|--|----------------|
| General Service over 50 kW Rate Class  | 8 participants |
| General Service under 50 kW Rate Class | 8 participants |

#### Hamilton: January 15, 2014

| Community and Industry Stakeholders    | 8 participants |
|--|----------------|
| General Service over 50 kW Rate Class  | 7 participants |
| General Service under 50 kW Rate Class | 7 participants |

#### Stakeholder and business customer assessment of Horizon Utilities' proposed rate increase:

Most participants (32 of 43) in the facilitated discussion groups gave Horizon Utilities permission to increase customer rates by the proposed amount; with 8 of 43 saying they support the proposed rate increase and 24 of 43 saying they don't like it, but think it is necessary. On the contrary, 8 of 43 participants believe the rate increase is unreasonable and oppose it.

Most of the opposition to the proposed rate increase came from general service customers in the over 50 kW rate class. The main reasons provided among customers opposed to the proposed rate increase was their limited ability to pay and the impact it would have on their competitiveness with other firms in lower-cost jurisdictions.

Those who provided permission believed the plan seemed reasonable and was necessary to maintain system reliability.

| Q: Based on what you know and have heard today about Horizon Uplan, which of the following best represents your point of view? | Jtilities' |
|--|------------|
| The proposed rate increase is reasonable and I support it  | n=8        |
| I don't like it, but I think the proposed rate increase is necessary   | n=24       |
| The proposed rate increase is unreasonable and I oppose it   | n=1        |
| Don't know   | n=1        |
| Missing Responses  | n=2        |

#### Phase 3: Residential Ratepayer Survey

The residential ratepayer survey was conducted by telephone among 1,011 residential customers of Horizon Utilities, who were randomly selected from a client provided list between January 22<sup>nd</sup> and 29<sup>th</sup>, 2014. A sample of this size is considered accurate to within ±3.1 percentage points, 19 times out of 20. The margin of error will be larger within each sub-grouping of the sample.

The residential ratepayer survey was informed by feedback collected in phases one and two of the customer consultation.

#### Residential customer permission on Horizon Utilities' proposed rate increase:

Almost three-quarters of respondents (73%) in the residential customer survey give Horizon Utilities "permission" for the proposed rate increase – that is, they either *think the proposed rate increase is reasonable and support it* <u>OR</u> say that they *don't like it, but think it is necessary*. A quarter of respondents (24%) think *the proposed rate increase is unreasonable and oppose it*.

| Q: Based on what you know and have heard today about Horizon Uti<br>plan, which of the following best represents your point of view? | lities' |
|--|---------|
| The proposed rate increase is reasonable and I support it  | 32%     |
| I don't like it, but I think the proposed rate increase is necessary   | 41%     |
| The proposed rate increase is unreasonable and I oppose it   | 24%     |
| Don't know / Refuse  | 3%      |

When asked why they said they would support a rate increase, almost half of respondents (47%) gave the answer because "the improvements are necessary", followed by the "increase is affordable" (42%).

For those who said they don't like the rate increase, but thought it is necessary, the most common reason provided was also that they believe the "improvements are necessary" (32%), followed by "the investment is necessary" (23%).

As for those who think the rate increase is unreasonable, 48% say that it is because "the increase is too high", followed by concerns with both "executive compensation" (13%) and "poor fiscal management at Horizon Utilities" (13%).

#### Phase 4: Key Account Validation Interviews

A dozen Key Account customers were consulted on the proposed 5 Year DSP by Horizon Utilities staff. INNOVATIVE followed-up by telephone with 9 of the 12 Key Accounts after their consultation session to validate the process and to verify that Horizon Utilities provided these customers with the information they needed to provide informed feedback on the proposed plan.

Most Key Accounts (6 of 9) gave Horizon Utilities permission to change the rates by the proposed amount; with 5 of 9 saying they support the proposed rate change and 1 of the 9 saying they don't like it, but think it is necessary. On the contrary, 3 of 9 participants believe the rate change is unreasonable and oppose it.

It is important to note that the three Key Account customers who opposed the rate change are classified under general service customers over 50 kW rate class, but are consulted as Key Accounts because they represent a number of facilities that cumulatively, would place them in the larger user rate class.

#### Key account customer permission on Horizon Utilities' proposed rate change:

| Q: Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view? |      |
|--|------|
| The proposed rate <i>change</i> is reasonable and I support it   | n= 5 |
| I don't like it, but I think the proposed rate <i>change</i> is necessary  | n= 1 |
| The proposed rate <i>change</i> is unreasonable and I oppose it  | n= 3 |
| Don't know   | n= 0 |
| Missing Responses  | n= 0 |

## **Other Key Findings**

#### Customer Needs are Largely Being Met, Key Concern is Cost

Overall, customers report Horizon Utilities is doing a good job of meeting their needs:

- 92% of customer online workbook respondents report being very or somewhat satisfied;
- 38 of 41 workbook-based facilitated discussion participants report being very or somewhat satisfied: and
- 88% residential telephone respondents report being very or somewhat satisfied.

When asked what Horizon Utilities can do to improve its services, a common initial theme was that Horizon Utilities should keep rates down.

- In the online workbook, most respondents had no specific suggestions. Among those with comments, respondents wanted lower rates, better reliability or a more modern system (often the two ideas were connected) and a more environmentally friendly system.
- In the facilitated discussion groups, most participants were willing to make suggestions for improvements including lower rates and better communications during outages.

• In the residential telephone survey, just under half the respondents had suggestions for improvement with most comments focused on lowering rates.

Most participants in the online workbook and discussion groups experienced a power outage in the past year. A majority of telephone respondents experienced a weather related outage due to the summer wind storm and December ice storm and 35% experienced a routine outage.

We asked online and discussion group participants how well Horizon responded to the outages:

- In the customer online workbook, 84% were satisfied with Horizon Utilities' response to the outage.
- In the workbook-based facilitated discussion groups, 28 of 35 participants were satisfied.

# Customer Focus More on Length of Outages than Number, Limited Interest in Paying More for Improvements

Moving to preferences, online respondents and facilitated discussion group participants were asked what the acceptable number of annual power outages and length of time for each power outage would be. Most customers indicated that they would tolerate between 1 or 2 power outages a year with roughly 30 minutes to 1 hour without power was acceptable.

We also asked which was more important, focusing on number of outages or the duration.

- The most common answer among customer online workbook respondents was both (54%) but among those who prioritized one over the other, 32% said focus on duration while 10% said focus on the number of outages.
- There was good discussion of this choice in the facilitated discussion groups, where GS customers shared the practical consequences of power outages on their business. For instance, machine shop operators with automated systems reported a very significant disruption cost for any outages no matter how long the outage. Not all customers appear to have access to "behind the meter" technologies to minimize this risk. However, for most businesses and services, the length of a power outage was more important than the frequency. Short outages could be managed, but outages of more than an hour or two meant sending staff home and losing the day. Good communications providing realistic estimates of restoration time are key to minimizing the impacts.

In the residential telephone survey the focused was more on the trade-off between cost and benefits. For both number of outages and duration of outages, residential customers were asked whether Horizon Utilities should "spend what it takes to improve performance", "spend what it takes to maintain performance" or "accept lower performance to keep costs down". The "spend what it takes to maintain performance" category reflects the growing number of interruptions caused by equipment failure and the increase in capital required just to sustain service.

- On the number of outages, the largest number (46%) of residential respondents chose spending
  what is needed to maintain the current level, with spending what is need to reduce the number
  (26%) gaining somewhat more support than accepting more outages in order to keep customer
  costs down (16%).
- On length of outages, the largest number (48%) of residential respondents chose spending what is needed to maintain the current level, with spending what is need to reduce the number (25%) gaining somewhat more support than accepting more time without electricity in order to keep customer costs down (17%).

## Customers In Agreement With Key Horizon Utilities' Investment Choices

Looking at capital investment issues, we also found our questions evolving between the first two phases and the telephone survey. In the online workbook and the facilitated discussion groups, customers agree with Horizon Utilities on their "run-to-failure" strategy:

- More than 3-in-5 online workbook respondents (61%) said that "running- to-failure" is a good
  way to get full value from equipment so long as the resulting power service interruption is
  contained. In contrast, only a quarter of respondents (26%) agreed that Horizon Utilities should
  not wait until equipment fails to replace it.
- 33 of 41 facilitated discussion group participants support running-to-failure as opposed to 8 of 41 who support replacing equipment before it fails.

The online workbooks and the discussion group workbooks were able to lay out the Horizon Utilities plan in more detail through the workbooks than the telephone survey. Online workbook and the discussion group participants felt the rate of investment made sense:

- 61% of the online participants said the proposed rate of system renewal seemed "about right" with 14% saying "too fast" and 6% "too slow".
- 24 discussion participants felt the rate was "about right" with 6 saying "too fast" and 3 saying "too slow".
- 3 of 8 key account customers believe the pace of Horizon Utilities' proposed system renewal plan is "about right", while another 3 of 8 believe it is "too slow". The remaining key account customers (2 of 8) who provided feedback on pacing, believe the plan is moving "too fast".

Those who said "too fast" are primarily concerned about cost while those who say "too slow" are concerned about the possible negative impacts of system renewal delays or see immediate need for improvement.

The telephone survey focused more on basic trade-offs.

- After a brief overview of Horizon Utilities' renewal plan, just over half (57%) of residential consumers preferred that Horizon Utilities should invest what it takes to replace aging infrastructure even if rates go up while 29% chose reducing the level of investment, even if that means more or longer power outages.
- On new technology, 64% agreed "... new technology will increase system reliability, make our local distribution system more efficient, and save us money in the long run" while 28% chose "... investments in new technologies are more of a luxury than a necessity and will cost customers more than they are willing to pay".
- On general plant, 64% picked "While Horizon Utilities should be wise with its spending, it is important that its staff have the equipment and tools they need to manage the system efficiently and reliably" while 29% preferred "Horizon Utilities should find ways to make do with the buildings, equipment and IT systems it already has".

## Comments Outside the Scope of the Consultation

There were several consistent comments received primarily through the discussion groups that are outside the specific scope of the consultation, but need to be noted to keep faith with the participants.

- 1. Both industry stakeholders and general service customers over 50 kW expressed concerns about the cumulative impact of rising electricity costs. Unlike service based businesses that can more readily pass costs onto their customers since their competitors share a common cost base, many manufacturers are unable to pass on costs as their products are sold in competitive, international markets. A number suggested that rate increases could put them at a disadvantage to competing firms operating in jurisdictions with lower electricity costs. Some participants reported they knew specific companies which already left the local market due at least in part to rising electricity costs. They often made the point that they understand the business case for higher rates in this consultation, but they simply have no room to absorb the increases. They feel decision-makers need to consider the total competitive impact of rising electricity costs and come up with a solution for these "price-taking" businesses.
- 2. Another group that has limited ability to cope with higher rates is low and fixed income residential customers. While this particular increase is manageable for some, they also expressed concern about the cumulative impact of rising electricity bills beyond the portion managed by Horizon Utilities. Consumers were interested in learning if there were Horizon Utilities programs available for low-income households to offset the impact of a rate increase. Some community stakeholders were aware of some Horizon Utilities programs for low-income households having trouble with their bills and expressed support for those programs.
- 3. Participants in every discussion group questioned the long-term financial processes of this sector. They did not understand why under the regulated process, Horizon Utilities did not save money in a reserve fund in anticipation of system renewal requirements. Business owners and managers in particular did not understand why there are no savings for these expenditures. They often explained that they, as business people, have to budget and put earnings aside in anticipation of replacing their equipment and business tools; "so why can't Horizon Utilities do the same"? The OEB may wish to consider this view.
- 4. A number of community stakeholders would have liked to have seen more information on education programs available to constituents on reducing electricity consumption.
- 5. Some participants were hoping to see more information on Horizon Utilities' energy sustainability policies within the local distribution system.

## **Customer Consultation Overview**

## **Effective and Meaningful Consultation**

Engaging customers in any meaningful consultation can be a challenge. The reality of most consultation processes is that they aim to collect the views of the average person, but result in collecting the views of organized advocacy groups.

While, many customers feel they do not know enough to contribute to a public consultation, others fear the combative nature of some public processes or prefer not to risk offending friends and neighbours by taking firm positions on issues that are sometimes controversial. Moreover, many customers simply do not pay attention and remain unaware of particular consultations that they would participate in if they had been aware of the consultation.

How do organizations get past these hurdles to run a consultation process that will bring together a representative group of stakeholders and give them an opportunity to immerse themselves in complicated and sometimes controversial issues like electricity infrastructure and distribution system renewal?

INNOVATIVE's perspective on developing and executing meaningful customer engagement is to combine best practices from both the traditional consultation and opinion research disciplines.

Working in concert with Horizon Utilities staff, INNOVATIVE designed a multifaceted customer engagement program which included a combination of traditional consultation services as well as qualitative and quantitative research elements. This comprehensive consultation was designed to engage various rate classes and collect feedback on preferences and priorities as they relate to Horizon Utilities' 5-Year Distribution System Plan.

#### **Traditional Consultation Elements:**

• This included an online workbook to collect feedback from Horizon Utilities' customers who elected to participate in the consultation process.

### **Opinion Research Elements:**

There were three opinion research elements in this process:

- Independent telephone follow-up surveys with Key Accounts who participated in the Horizon interviews. The independent follow-up survey that was conducted by INNOVATIVE documented the level of satisfaction these Key Accounts experienced with the consultation process.
- Workbook-based discussion groups with community and industry stakeholder groups as well as
  randomly recruited Horizon Utilities general service (GS) customers. GS customers who participated
  in the discussion groups were provided with an incentive to ensure they represent Horizon Utilities
  customers from all walks of life and all points of view.
- As well, we conducted a telephone survey of randomly-selected residential customers to ensure Horizon Utilities captured the viewpoint of the average customer in their largest rate class.

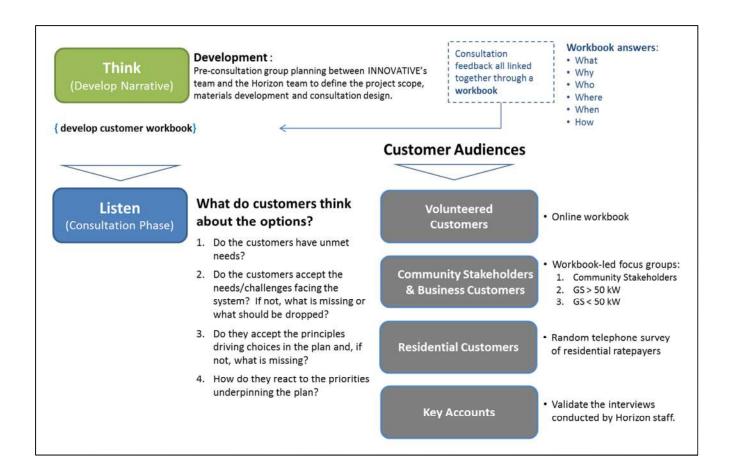
The traditional consultation elements were designed so anyone could participate in the process, while the opinion research elements provided various vehicles for systematically sampling the views of each rate class.

## Horizon Utilities' Consultation Roadmap

The consultation had four phases of customer engagement.

- 1. **Customer Online Workbook**: The online workbook was promoted through traditional print advertising and social media as well as Horizon Utilities' website. This first phase of the consultation was available to all Horizon Utilities customers who wanted to participate.
- 2. Workbook-based Facilitated Discussion: Community stakeholders and business customers were also engaged through a series of workbook-led focus groups. Community stakeholders were identified by Horizon Utilities and invited by INNOVATIVE to participate in the consultation discussion groups which were held during business hours in the afternoon. Business customers (general service customers both under and over 50 kW) were randomly recruited by INNOVATIVE for evening consultation discussion groups and were provided incentives in recognition of their time commitment.
- 3. **Residential Ratepayer Survey**: The next phase of the consultation was a telephone survey of 1,011 Horizon Utilities residential customers. These customers were randomly selected from Horizon Utilities' customer contact database. Although the residential ratepayer survey followed a similar format of the workbook, much of its design was informed by feedback from phases one and two of the customer consultation.
- 4. **Key Account Validation Interviews**: Key Accounts were consulted on the proposed 5-Year DSP by Horizon Utilities staff. INNOVATIVE followed-up by telephone with large users after their consultation session to validate the process and to verify that Horizon Utilities provided these customers with the information they needed to provide informed feedback on the proposed plan. The key account validation interviews were in conducted in parallel with Phases 1, 2 and 3 of the customer engagement consultation. Where appropriate, comments from the earlier interviews were considered in developing the final residential survey.

An overview of Horizon Utilities' consultation roadmap is illustrated in the diagram below.



## **Workbook Development**

The workbook is the key component to this consultation, laying the foundation for all customer engagement. It is well documented in the OEB's own research that most electricity customers have little understanding of the design and operation of Ontario's electricity system. While it is possible to identify customer needs without any further information, it is not possible to identify preferences regarding Horizon Utilities' capital plan without going through some process of education.

The workbook provided customers the opportunity to learn about Horizon Utilities' Plan and provided a channel for customers to share their feedback. The consultation workbook was the core tool used to ensure alignment between Horizon Utilities' 5-Year DSP and their customers' preferences and priorities.

The process of developing the workbook began in the fall of 2013. Horizon Utilities and INNOVATIVE staff worked together to develop an accessible customer consultation workbook designed to both inform customers of the 5-Year DSP and collect customer feedback.

The workbook was divided into key sections that explained Horizon Utilities' electric system, the challenges facing the system, and how Horizon Utilities intended to meet those challenges over time.

The workbook had seven distinct chapters:

- 1. What is this about?
- 2. Electricity Grid 101

- 3. Horizon Utilities' Distribution System Today
- 4. Challenges Facing Our Distribution System
- 5. Controlling Costs
- 6. What Our Plan Means For You
- 7. About Horizon Utilities Corporation

Although the sophistication of customers varied, the structure of the consultation workbook was used in all customer engagements (with varying levels of details<sup>2</sup>). As the customer went through the consultation workbook – either independently or through a facilitated session – they were prompted with questions related to system reliability, system challenges, and preferences on the direction of Horizon Utilities proposed Distribution System Plan.

The workbook can be found in the **Appendix** of this report.

<sup>2</sup> Key Account consultations, conducted by Horizon Utilities staff, would have followed the consultation workbook structure, however the educational component such as "Electricity 101" were often skipped as these customers are far more knowledgeable of the local electric system than the average customers.

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# Phase 1: Customer Online Workbook

# **Summary**

The following summary highlights key findings from residential customer feedback collected through an online workbook tool designed for Horizon Utilities. Responses to the online were voluntary and collected between December 11, 2013 and January 13, 2014. The results are based on completed answers to the online workbook questions, ranging from 140 to 103 responses.<sup>3</sup>

## **Experiences and Expectations with Power Service Interruptions**

- Almost all residential respondents (82%) who filled out the online workbook experienced a power service interruption in the last year, and for most it lasted for an hour or less.
- However, there was a high level of satisfaction concerning Horizon Utilities' response to their most recent power service interruption. In terms of Horizon Utilities' response to the most recent power outage, 84% of residential respondents said they were satisfied while only 7% said they were dissatisfied.
- A plurality agrees (34%) that two power service interruptions a year is reasonable. Concerning the duration, almost three-quarters of respondents (72%) said that a period of less than an hour is acceptable for a service interruption.
- When given the option between focusing on number of power service interruptions or duration of the interruptions, a majority of people agree that Horizon Utilities should focus on both.

#### Improving Service of the Local Distribution System

- Almost all residential respondents (92%) are satisfied with the job Horizon Utilities is doing running
  the local distribution system. When asked about improvements, the main suggestions concerned
  reducing the price and improving the reliability of the service.
- A majority of people (61%) support the system policy of "running-to-failure" as long as the resulting power service interruption is contained and quickly restored. Only a quarter of respondents (26%) agree that Horizon Utilities should not wait until equipment fails to replace it.

## **Coverage of Distribution System Topics**

• For the most part, the online documentation provided respondents with the information they needed to answer the questions contained within the workbook.

<sup>&</sup>lt;sup>3</sup> A total of 103 residential customers completed Horizon Utilities' Online Workbook. However, an additional 37 residential customers completed at least the respondent profiling questions within the Online Workbook. Answers from these 37 semi-complete respondents are included for questions they completed. Business customers are not included in the Executive Summary results as only 11 such customers completed or semi-completed the Online Workbook.

 Nearly three-quarters (73%) of residential respondents agreed that the Horizon Utilities' Distribution System Plan Review covered the topics they would have expected. 1-in-5 (20%) don't know whether the Workbook covered the topics they expected, while 7% felt topics were missing.

#### System Renewal and Rate Impact

- When asked what they thought of the proposed pace of system renewal, 61% of residential
  customers felt the rate is "about right". The main reason stated for this view was that the proposed
  investment plan seemed reasonable.
- More than 6-in-10 (62%) respondents give Horizon Utilities permission to increase residential rates
  by the proposed amount; with 20% saying they support the proposed rate increase and 42% saying
  they think it is necessary. On the contrary, 32% of residential respondents are opposed to the rate
  increase, while 6% don't know or don't have an opinion either way. The main reasons provided for
  permission were that paying now avoids rising costs later and that the rate increase is fair.

#### Customer permission on Horizon Utilities' proposed rate increase:

Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view?

| The proposed rate increase is reasonable and I support it            | 20% |
|--|-----|
| I don't like it, but I think the proposed rate increase is necessary | 42% |
| The proposed rate increase is unreasonable and I oppose it           | 32% |
| Don't know   | 6%  |

# Methodology

#### **About the Online Workbook**

In the fall of 2013, Horizon Utilities and INNOVATIVE staff began developing an accessible customer workbook designed to both inform customers of the 5-year distribution system plan and collect customer feedback.

The online workbook was divided into key sections that explained Horizon Utilities' electric system, the challenges facing the system, and how Horizon Utilities intended to meet those challenges over time. The online workbook had seven distinct chapters:

- 1. What is this about?
- 2. Electricity Grid 101
- 3. Horizon Utilities' Distribution System Today
- 4. Challenges Facing Our Distribution System
- 5. Controlling Costs
- 6. What Our Plan Means For You
- 7. About Horizon Utilities Corporation

As the respondents went through the online workbook, they were prompted with questions related to system reliability, system challenges, and what the distribution system plan means to them. In total, the

online workbook contained 15 questions, with opportunities for open-ended responses and additional comments. All responses were anonymous and kept strictly confidential.

For customers, this is the opportunity to learn more about Horizon Utilities' plan and share their feedback. The ultimate goal was to ensure alignment between Horizon Utilities' operational plans and their customers' preferences and priorities.

Customer feedback was also incorporated into the design of subsequent consultation phases.

#### Field Dates:

The online workbook was available for Horizon Utilities' customers to access for 34 days, between December 11, 2013 and January 13, 2014.

#### **Promoting the Online Workbook:**

The online workbook was promoted by Horizon Utilities through traditional print advertising (the Hamilton Spectator and the St. Catharines Standard), Horizon Utilities' web site and Horizon Utilities' social media accounts, including Facebook and Twitter.

#### **Hosting the Online Workbook:**

The online workbook was hosted by INNOVATIVE under the URL: www.HorizonUtilitiesWorkbook.com.

The online workbook was designed to prevent respondents from completing the questions more than once and to save the progress of respondents in the event of survey mid-termination.

Cookies are small amounts of data that attach to a user's computer's hard drive when they visit a web site. Cookies were used in the design of the online workbook ensure that respondents only complete the online workbook once. When respondents reached the final webpage, the survey was considered complete and the site was no longer accessible to the internet protocol (IP) address used to complete the online workbook.

At the same time, the site saved respondent answers if they left the online workbook or experienced a mid-termination before reaching the final webpage of the workbook. When respondents returned to the online workbook, all previously entered answers were saved and appeared in the Workbook linked to the user's internet protocol (IP) address.

We do not link the information we store in cookies to any personally identifiable information submitted on our site.

Respondent feedback data was only ever available to INNOVATIVE project team staff through a secure data retrieval portal.

#### **Validating Customer Responses:**

Respondents who visited the online workbook were asked to self-identify as either a residential or business customer of Horizon Utilities. Respondents were then asked to provide the postal code that corresponded to either their residence or business and answer the remaining questions from the perspective of the self-identified customer type.

Horizon Utilities provided INNOVATIVE with a list of all valid customer postal codes which were crossed referenced against respondents who answered the questions in the online workbook. Only feedback from customers who provided a valid postal code was included in this report.

Using this method, only 4 respondents were removed from the sample.

#### **Sample Characteristics:**

Valid responses to the online workbook are as follows:

- 1,049 unique visitors came to the online workbook's landing page.
- 333 unique visitors continued beyond the landing page.
- 151 customers completed at least the profiling section of the online workbook (140 residential/11 business customers).
- 111 customers completed the entire online workbook by answering all questions (103 residential/8 business customers).

**NOTE**: This first phase of the consultation was available to all Horizon Utilities customers who wanted to participate and provide feedback. Results contained within this report are based on a limited and non-representative sample of volunteered respondents and should be interpreted as directional only.

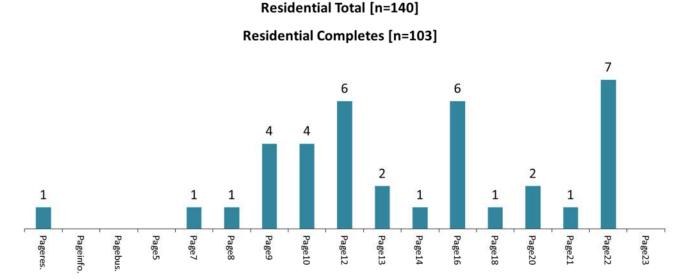
To ensure customer privacy, answers were grouped together with those of others who completed the same question and the information provided was used for statistical purposes only.

The total number of residential customers who completed the profiling section of the workbook was 140. However, 37 of the 140 residential customers did not fully complete the online workbook. Thus, the total number of residential respondents that finished the entire online workbook was 103.

Figure 1.1 below illustrates the progress made by the 37 respondents who did not complete the online workbook.

Although 37 of 140 residential respondents did not complete the entire online workbook, their answers to questions were documented and are included in the **Respondent Feedback** sub-section of this report.

Figure 1.1: Online Workbook Progress Rates



**Note:** Business respondents not shown. Business Total [n=11]. Business respondents who finished [n=8] "Page 9" [n=1] and "Page 12" [n=2]

#### **Business Respondents:**

While Figure 1.1 only provides data concerning residential respondents (who made up 93% of the respondents), a number of business respondents also completed the online workbook.

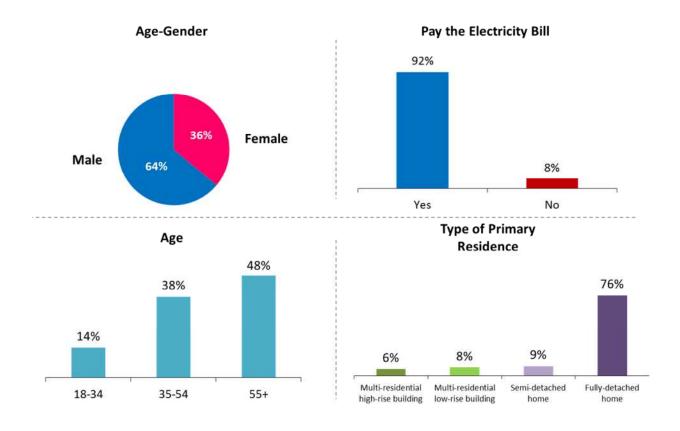
For business respondents, a total of 11 respondents at least completed the profiling section of the online workbook. The total number of business respondents who completed the online workbook was eight.

## **Respondent Profile**

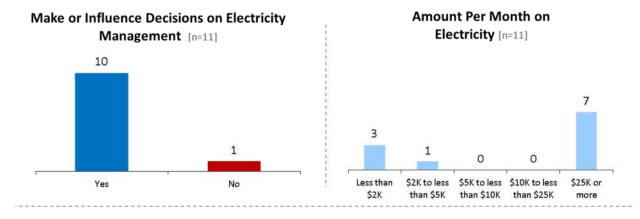
The following details the demographic characteristics of respondents who completed the profiling section of the online workbook [n=140 residential and n=11 business customers].

**NOTE**: In this section of the report, residential customer responses are represented by percentages, while business customer responses are represented by the actual number of respondents or "n-size" due to the small sample size of this customer group.

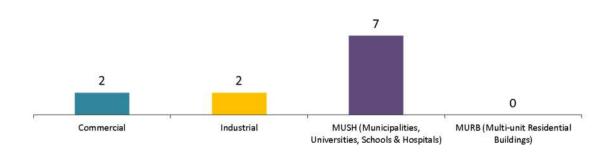
Figure 1.2: Residential Customer Profile



**Figure 1.3: Business Customer Profile** 







# Respondent Feedback

A total of 103 residential customers completed Horizon Utilities' online workbook. However, 140 residential customers completed at least the profiling questions within the online workbook. Answers from these 140 semi-complete respondents have been included in the findings of this report.

Responses provided by business customers are not included in the following charts as only 11 such customers completed or semi-completed the online workbook.

## **System Reliability**

This section of the workbook explores experiences with power service interruptions and measures respondents' expectations of the frequency and length of these interruptions.

#### **Experiences with Power Service Interruptions**

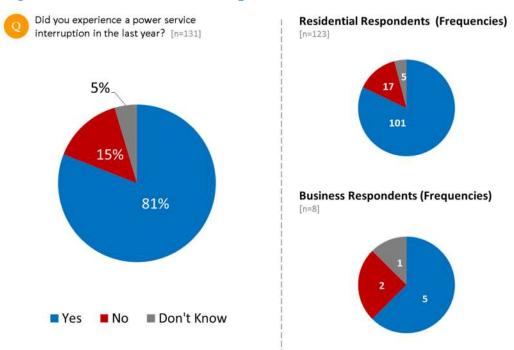
- Most respondents (82% of residential) experienced a power service interruption in the last year and for most the interruption lasted for less than an hour.
  - For business respondents, 5 out of 8 experienced a power outage and the interruption period varied across the respondents.

- Most respondents are satisfied with Horizon Utilities' response to power service interruptions. 84% of residential respondents said they were satisfied while only 7% said they were dissatisfied with the response.
- Just under half of respondents (46%) agreed Horizon Utilities response to power service interruptions is getting better while only 7% said it is getting worse.
  - Of the 8 business respondents who answered this question, 3 indicated Horizon Utilities' response is getting better, while only 1 respondent stated it is getting worse.

#### **Expectations of Power Service Interruptions**

- A plurality agrees (34%) that two power service interruptions a year is reasonable. This is followed by the acceptance of one outage, then none, then three, then four and finally more than four service interruptions per year.
- About three-quarters of respondents (72%) said that less than an hour without power is a reasonable duration for a service interruption. A plurality of those respondents indicated that around 30 minutes for a power outage is the most reasonable.
- The majority of people agreed Horizon Utilities should focus on both reducing the number of power service interruptions and reducing the duration of the outages.
  - Between focusing on the number of power service interruptions or the duration of interruptions, more people supported reducing the length of time the power is out over reducing the number of power outages.

## **Figure 1.4: Power Service Interruption**

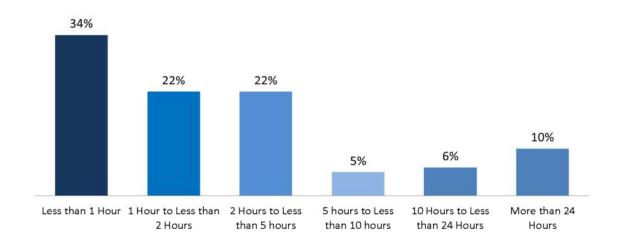


## Figure 1.5: Length of Power Service Interruption



If so, how long did your most recent power service interruption last?

[asked only of respondents who said they experienced a power service interruption in the last year; n=93]



Note: Business respondents not shown [n=5].

"Less than 1 hr." [n=1],"1 hr. to less than 2 hrs." [n=1],"2 hrs. to less than 5 hrs." [n=0],"5 hrs. to less than 10 hrs." [n=1],"10 hrs. to less than 24 hrs." [n=1] and "More than 24 hrs" [n=1]

Most residential and business respondents experienced a power service interruption in the last year. Among residential respondents, 82% indicated they had a power outages, 14% said they had not experienced one and 4% said they didn't know.

Concerning the length of the power outage, about 1-in-3 (34%) said the power was out for less than an hour. This was followed by 1 to 2 hours and 2 to 5 hours (22% each), then more than 24 hours (10%), then 10 to 24 hours (6%) and finally 5 to 10 hours (5%).

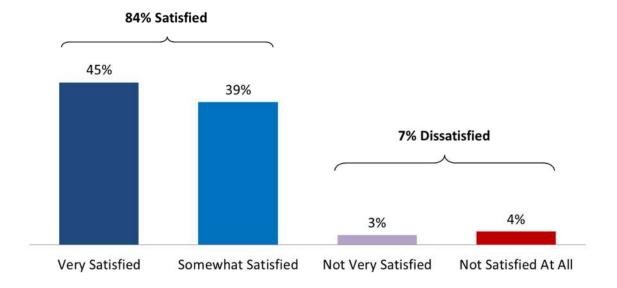
For business respondents, 5 out of the 8 respondents who answered the question experienced a service interruption. The length of time the power was out ranged from less than one hour to more than 24 hours.

#### Figure 1.6: Satisfaction with Horizon Utilities' Response



If you did experience a power service interruption, how satisfied were you with the way that Horizon Utilities responded to that power service interruption?

[asked only of respondents who said they experienced a power service interruption in the last year; n=109]



**Note:** 'Don't know' (9%) not shown Business respondents also not shown [n=6].

Most respondents were satisfied with that way that Horizon Utilities' responded to their power service interruption. Overall, 84% of residential respondents indicated they were satisfied while only 7% said they were dissatisfied. It should be noted that close to half of these respondents (45%) said they were "Very Satisfied" with Horizon Utilities' response.

Concerning business respondents, 3 out of 6 respondents indicated they were satisfied with Horizon Utilities' response while 2 respondents indicated they were "Not Very Satisfied".

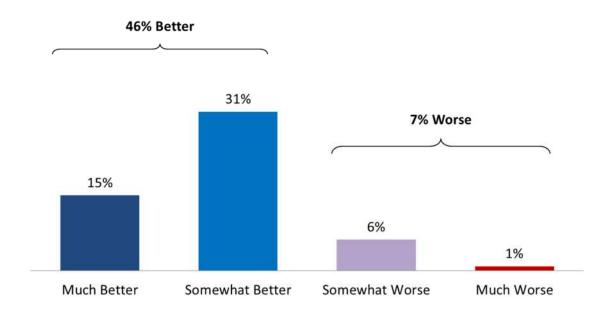
<sup>&</sup>quot;Very Satisfied" [n=1], "Somewhat Satisfied" [n=2],"Not Very Satisfied" [n=2],

<sup>&</sup>quot;Not Satisfied At All" [n=0] and "Don't Know" [n=1]

Figure 1.7: Improvement of Response



Is Horizon Utilities' response to power service interruptions getting better or worse? [n=123]



Note: 'Don't know' (47%) not shown Business respondents also not shown [n=8] "Much Better" [n=1], "Somewhat Better" [n=2], "Somewhat Worse" [n=1], "Much Worse" [n=0] and "Don't Know" [n=4]

Almost half (46%) of residential respondents indicated that Horizon Utilities' response to power service interruptions is getting better while only 7% said that it is getting worse.

• 15% of respondents said that Horizon Utilities is getting "Much Better".

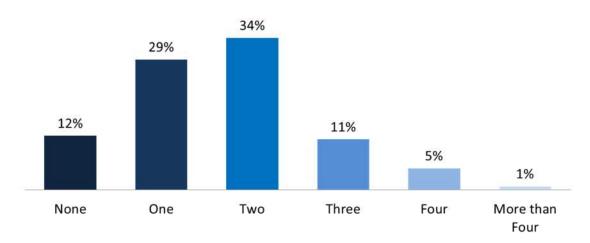
Of the 8 business respondents who answered this question, 3 of them indicated Horizon Utilities' response is getting better while only 1 respondent indicated it is getting worse.

Figure 1.8: Reasonable Frequency of Power Service Interruptions



#### Please answer the following questions from your point of view:

How many power service interruptions are reasonable in a year? [n=123]



Note: 'Don't know' (7%) not shown.
Business respondents also not shown [n=8]
"None" [n=0], "One" [n=2], "Two" [n=2], "Three" [n=1], "Four" [n=0], "More than four" [n=1] and "Don't Know' [n=2]

According to residential respondents, two power service interruptions a year is the most reasonable.

• After two power service interruptions a year, one is seen as the next most reasonable (29%), followed by none (12%), followed by three outages (11%), then four outages (5%) and finally more than four (1%) outages per year.

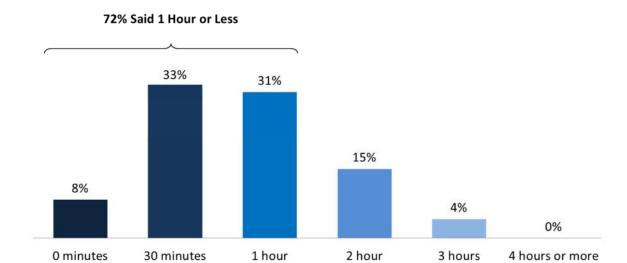
Business respondents indicated that one or two outages per year are most acceptable while three or more are less acceptable.

## Figure 1.9: Reasonable Duration for Service Interruption



Please answer the following questions from your point of view:

What is a reasonable duration for a service interruption? [n=123]



Note: 'Don't know' (10%) not shown.
Business respondents also not shown [n=8].
"0 min." [n=1],"30 min." [n=2],"1 hr." [n=2],"2 hrs." [n=0],"3 hrs." [n=0],

About 3-in-4 residential respondents (72%) said that less than an hour without power is a reasonable duration for a service interruption. A plurality of those respondents indicated that around 30 minutes for a power outage is the most reasonable.

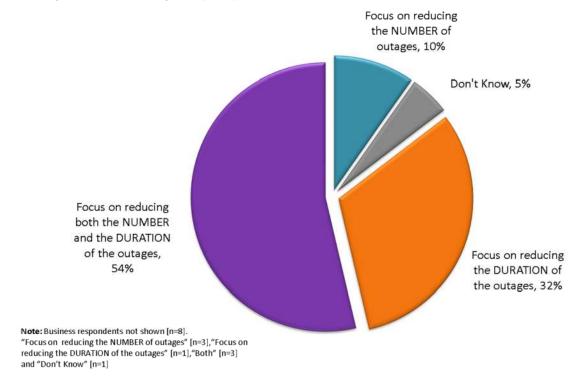
Business respondents stated that 30 minutes (n=2) or 1 hour (n=2) is the most reasonable duration for a service interruption.

<sup>&</sup>quot;4 hrs. or more" [n=1] and "Don't Know" [n=2]

Figure 1.10: To Focus on the Frequency or Duration of Power Service Interruptions



From your perspective, if Horizon Utilities is able to improve the reliability of its distribution system, should they put more focus on reducing the number of power service interruptions or reducing the duration of the power service interruption? [n=123]



The majority of residential respondents (54%) would like Horizon Utilities to focus on both the number and duration of power service interruptions. However, between reducing the number of power outages and reducing the duration of the outages, more people support reducing the duration over the number (32% versus 10%) of power service interruptions.

For business respondents, 3 out of 8 respondents indicated Horizon Utilities should focus on both the number and duration of the interruptions. However, 3 respondents also indicated that reducing the number of outages is more important than reducing the duration.

## **Challenges Facing the Distribution System**

This section explores respondent views concerning service of the local distribution system. It focuses on the degree of satisfaction with the current system and means of improving the system in the future.

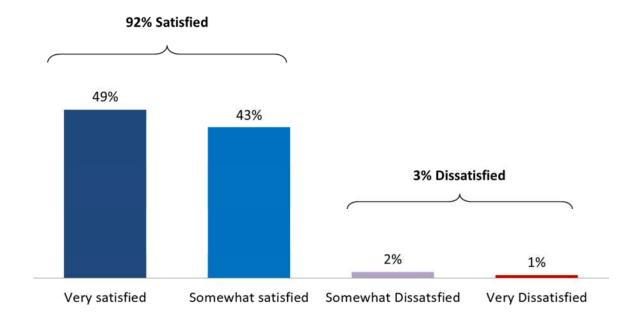
#### Improving Service of the Local Distribution System

- Nearly everyone (92%) is satisfied with the job Horizon Utilities is doing running the local distribution system. Only 3% of residential respondents indicated that they are dissatisfied.
- Reducing the price and improving the reliability of service were the main suggestions provided by respondents for improving Horizon Utilities' service. This is the case for both residential and business respondents.
- More than 3-in-5 respondents (61%) said that "running- to-failure" is a good way to get full value from equipment so long as the resulting power service interruption is contained. In contrast, only a quarter of respondents (26%) agreed that Horizon Utilities should not wait until equipment fails to replace it.

Figure 1.11: Satisfaction with Local Distribution System



How satisfied are you with the job Horizon Utilities is doing running your local distribution system? [n=115]



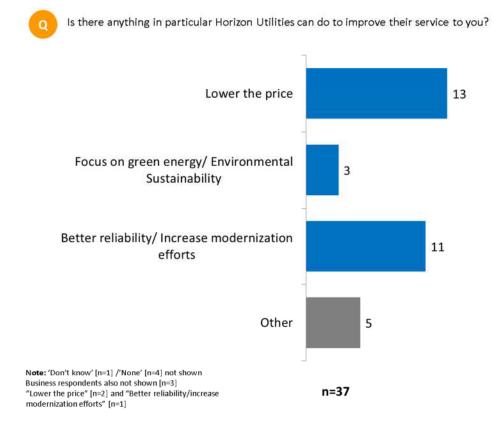
Note: 'Don't know' (5%) not shown Business respondents also not shown [n=8] "Very Satisfied" [n=2], "Somewhat Satisfied [n=5], "Somewhat Dissatisfied [n=1], "Very Dissatisfied" [n=0] and "Don't Know" [n=0]

Almost everyone (92%) is satisfied with the job Horizon Utilities is doing with running the local distribution system. Only 3% of residential respondents stated that they are dissatisfied in some way.

• Of those who are satisfied, half (49%) indicated that they are "Very Satisfied".

Business respondents are also satisfied with the job Horizon Utilities is doing as 7 out of 8 respondents indicated they are either "Very Satisfied" or "Somewhat Satisfied".

Figure 1.12: Improving Service

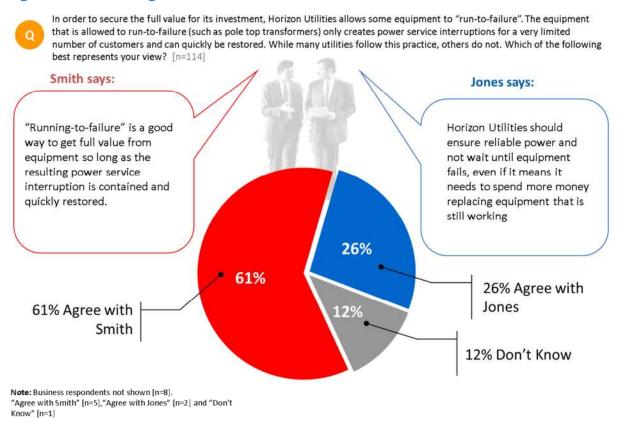


In particular, reducing the price and improving the reliability of service appear to be the most important things Horizon Utilities can do to improve their service.

• There were also suggestions for supporting green energy and improving environmental sustainability.

For business respondents, 2 out of the 3 respondents who provided an answer said lowering the price would improve service. The last respondent responded "Better reliability" would improve service.

## Figure 1.13: Running-to-Failure



Around 3-in-5 residential respondents (61%) think that "running-to-failure" is a good way to get full value from equipment as long as the resulting power service interruption is quickly restored. In contrast, only 26% agree that Horizon Utilities should not wait until equipment fails to replace it.

For business respondents, 5 out of 8 agreed with "running to failure" while 2 out of 8 respondents said that more money should be spent replacing equipment.

#### What the Plan Means for Customers

This section covers the feedback provided by the respondents on the workbook itself. It also measures attitudes toward changes to the local distribution system, specifically, addressing speed of changes and support or opposition to rate increases.

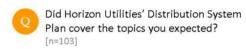
### **Coverage of Distribution System Topics**

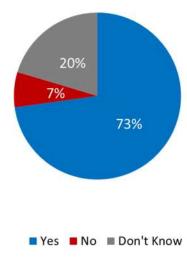
- Almost three-quarters (73%) agreed that Horizon Utilities' Distribution System Plan covered the topics they expected to be covered. In comparison, only 7% said there were topics missing from the Distribution Plan.
- For those who said topics were missing, various suggestions were brought up. .Specifically, savings for customers, potential changes in company structure, and the waste of power by people and businesses were suggested topics.
- More than 4-in-5 residential respondents indicated that they understand both how the distribution system works and the challenges of this system.

#### Changes to the Local Distribution System

- 61% of respondents feel the proposed rate of system renewal is just right. This is followed by 14% who indicated that it is moving too fast and 8% who indicated that the proposed rate of renewal is too slow.
  - The main reasons listed for those who said the proposed rate of renewal is too fast was that the cost is already too high and that the funds are spent unwisely.
  - The main reason for those who stated it is about right was that the proposal suggested seems reasonable.
  - For those who indicated the rate change is too slow, the two reasons provided were that the current power service interruption rate hurts businesses and that we shouldn't wait for the future to address potential problems.
- Concerning the rate increase proposal, over 3-in-5 (62%) stated they either support the proposal or at least think it is necessary. Only 32% of respondents believe that the rate increase is unreasonable.
  - The main reasons provided for supporting the rate increase were that paying now avoids rising costs later and that the rate increase is fair.
  - The most common answer for why respondents said they don't like the rate increase but they think it is necessary was that it is too expensive but they realize they don't have any other option.
  - Finally, for those that said they are opposed to the rate increase, the top reason given was that there is not enough accountability and there is already too much greed.

Figure 1.14: Distribution Plan Topics





- How to pass savings to customers -Potential changes in structure such as a merger of IESO and OPA and how this might affect distribution -The waste of power and how we are going to address it for our future -What is being done to eliminate the waste of power by OPG?

Note: Business respondents not shown [n=8] Yes" [n=5], "No" [n=2] and "Don't Know" [n=1]

Note: Business respondents not shown [n=0].

If no: What was missing?

expected; n=9]

[asked only of respondents who said no to "did Horizon

Utilities' Distribution System Plan cover the topics you

Sample Verbatim

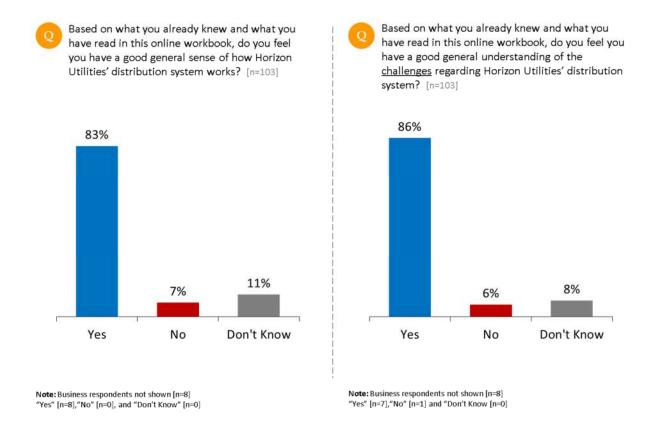
n=9

Almost three-quarters of residential respondents (73%) agreed that the Horizon Utilities' Distribution System Plan covered the topics they expected to be covered. Only 7% disagreed while 20% said that they didn't know what topics to expect.

When asked what was missing, various topics were brought up. .Specifically, savings for customers, potential changes in company structure, and the waste of power by people and businesses were suggested topics. Other verbatim comments were nonsensical or out of the scope of Horizon Utilities' 5-year Distribution System Plan.

Of the 8 business respondents, 5 indicated that the topics they expected were covered, 2 respondents said that the Distribution Plan did not cover their expected topics and 1 person said they didn't know.

Figure 1.15: Understanding the Distribution System and Its Challenges



Most residential respondents agreed that they have a good general understanding how Horizon Utilities' distribution system works as well as an understanding of its challenges.

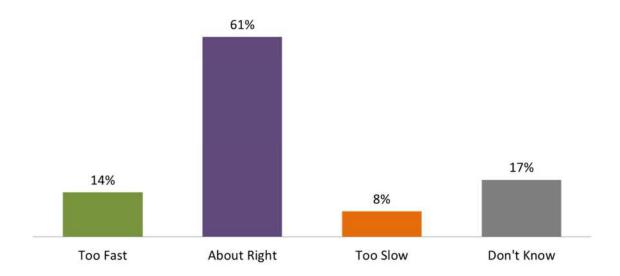
• Over 4-in-5 residential respondents indicated that they understand both how the distribution system works as well as the challenges of the distribution system.

Business respondents also overwhelmingly indicated that they understand how the system works (8 respondents out of 8). Furthermore 7 out of 8 business respondents said they understand the challenges regarding Horizon Utilities' distribution system.

## Figure 1.16: Pace of Proposed System of Renewal



Considering what you know and have learned about the local distribution system, do you feel the proposed rate of system renewal is...? [n=103]

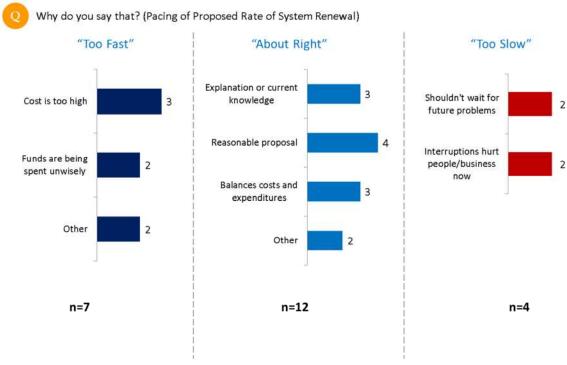


Note: Business respondents not shown [n=8]
"Too Fast" [n=3],"About Right" [n=3],"Too Slow" [n=1] and
"Don't Know" [n=1]

More than 3-in-5 residential respondents felt that the proposed rate of system renewal is about right. This is followed by 14% who indicated that it is moving too fast. Only 8% indicated that the proposed rate of renewal is too slow.

Of the business respondents, 3 out of 8 respondents said the pacing of the proposed system is too fast and 3 out of 8 said the pacing is about right. Only 1 business respondent said that the rate is too slow.

Figure 1.17: Reasons for Pacing of Proposed System Renewal



Note: Business respondents not shown [n=3]
"Too Fast" reason is "cost is too high" and "About Right" reason is "balances the expenditures"

The top reasons provided by those who agreed the proposed rate of system renewal is too fast were that the cost is too high and the funds already collected are being spent unwisely.

For those who said the proposed system of renewal is about right, the top reason for saying so was that the proposal put forward seemed reasonable. Other reasons provided were that the explanation they heard and their current knowledge made them think the speed was right and that the proposal seemed to balance costs and expenditures.

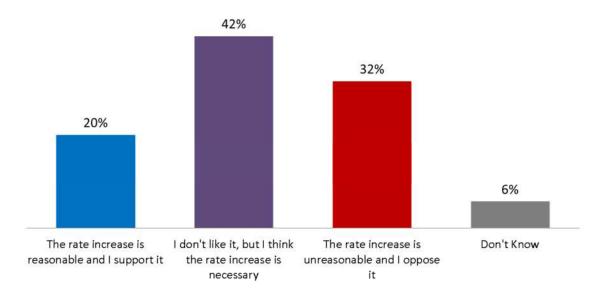
The two reasons provided by those who said the proposed rate of system renewal is too slow was that the current power service interruption rate hurts businesses and people now and that we shouldn't wait for the future to address potential problems.

Of the business respondents who answered the pacing of the proposal is too fast, their reason was that the "cost is too high". For those that said the speed is about right, their reason was that it "balances the expenditures".

## Figure 1.18: Permission on Rate Increase



Considering what you know and have learned about the local distribution system, do you feel the proposed rate of system renewal is...? [n=103]

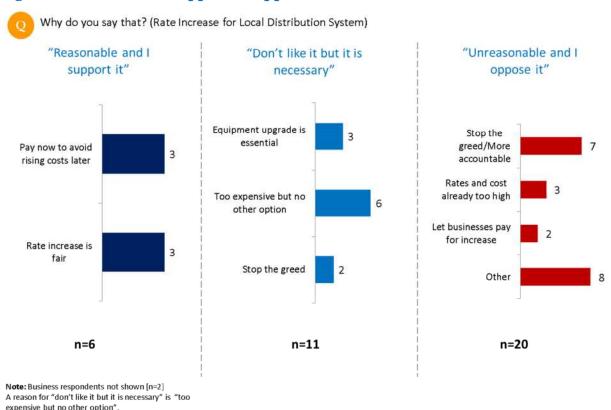


Note: Business respondents not shown [n=8] "The rate increase is reasonable and I support it [n=1],"I don't like it, but I think it is necessary "[n=3], "The rate increase is unreasonable and I oppose it "[n=3], and "Don't know' [n=1].

Overall, 62% of residential respondents agreed that the rate increase is at least necessary. Of those, 1-in-5 (20%) think the increase is reasonable and support it. Only 32% of respondents believe that the rate increase is unreasonable.

Of the business respondents, half (4 out of 8) said they don't like it but they think it is necessary.

Figure 1.19: Reason for Support or Opposition to Rate Increase



The main reasons provided for supporting the rate increase were that paying now avoids rising costs later and the rate increase is fair.

For those who said they don't like the proposal but think that it is necessary, most said they didn't like it because it is too expensive but they realize they do not have any other option. The second reason given is that equipment upgrade is essential for service.

The top reason provided by those in opposition to the rate increase was that there is not enough accountability and too much greed. Other reasons provided were that the rates are already too high and that businesses should pay for the increase.

For the business respondents who don't like the rate increase but think it is necessary, their reason for saying so was that "it is too expensive but there is no other option".

# Phase 2: DSP Workbook-based Facilitated Discussion

## **Summary**

The following summary highlights key findings from the community and industry stakeholder and general service consultation sessions held in St. Catharines and Hamilton.

#### System Reliability: Customer Experience and Expectation

- Most participants in the consultation groups have experienced power service interruptions at their businesses in the past twelve months. The duration of the service interruption lasted from a few minutes to many hours in some cases. The frequency of outages averaged around 2 to 3 power service interruptions per year.
- General Service customers in both groups reported losses of revenue and productivity within their respected businesses due to power service interruptions.
- Service-based businesses would like Horizon Utilities to concentrate on limiting the duration of the
  outages. For example, participants stated that if the duration of outages lasted more than two
  hours, customers would leave, there would be spoilage of food, and employees would not be able to
  work in the dark.
- Businesses in the manufacturing industry wanted Horizon Utilities to focus on limiting the frequency
  or number of power service interruptions per year. For example, participants in the manufacturing
  sector stated that every time there would be an outage their production equipment would be
  forced to shut down, and that the time required to reset their production equipment could lead to
  significant loss of productivity.

#### Improving Service of the Local Distribution System

- For the most part, stakeholder and general service customers are satisfied with the job Horizon
   Utilities is doing running the local distribution system. When asked about improvements, the main
   suggestions concerned limiting rate increases and reducing power service interruptions. A few
   suggested better customer communications around power outages.
- Both industry stakeholders and general service customers over 50 kW expressed concerns about electricity costs. Unlike service based businesses that can more readily pass costs onto their customers, many manufacturers are unable to pass on costs as their products are sold in competitive, international markets. A number suggested that rate increases could put them at a disadvantage to competing firms operating in jurisdictions with lower electricity costs. Ultimately, any electricity cost increases would have to be absorbed by this group of customers; a number of which stated they had little to no room to take on additional costs.

- A number of general service customers in Hamilton expressed concern over what they saw as poor fiscal management at Horizon Utilities. Specifically, participants questioned why Horizon Utilities did not have a reserve fund or had not saved money in anticipation of system renewal requirements. As owners and managers, this group of participants explained that they have to budget and put money aside to replace their equipment and business tools so why couldn't Horizon Utilities do the same?
- When it came to the policy of "running-to-failure", most participants support it and see this as a
  fiscally prudent approach to controlling system costs.

#### Coverage of Distribution System Topics

- A number of community stakeholders would have liked to have seen more information on energy
  sustainability policies and education programs available to constituents on reducing electricity
  consumption. Others would have liked to know if there were Horizon Utilities programs available for
  low-income households to offset the impact of a rate increase.
- Overall, participants in the consultation sessions felt the workbook did an effective job at covering
  the topics they expected and allowed them to have a meaningful discussion about Horizon Utilities
  distribution system plan.

#### System Renewal and Rate Impact

- Most participants felt the proposed pace of system renewal is "about right". That is, most agreed that the plan balanced the need to replace aging infrastructure with customer bill impacts.
- Most participants (32 of 43) give Horizon Utilities permission to increase customer rates by the
  proposed amount; with 8 of 43 saying they support the proposed rate increase and 24 of 43 saying
  they don't like it, but think it is necessary. On the contrary, 8 of 43 participants believe the rate
  increase is unreasonable and opposed it.
- Most of the opposition to the proposed rate increase came from general service customers in the
  over 50 kW rate class. The main reasons for their opposition are their limited ability to pay and the
  impact it will have on their competitiveness with other firms in lower-cost jurisdictions.
- Those who provided permission believed the plan seemed reasonable and was necessary to maintain system reliability.

#### Stakeholder and business customer permission on Horizon Utilities' proposed rate increase:

Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view? [based on 43 responses]

| The proposed rate increase is reasonable and I support it            | n=8  |
|--|------|
| I don't like it, but I think the proposed rate increase is necessary | n=24 |
| The proposed rate increase is unreasonable and I oppose it           | n=8  |
| Don't know   | n=1  |
| Missing Responses  | n=2  |

**NOTE**: A number of participants stated that with a rate increase should come an obligation on behalf of Horizon Utilities to proactively communicate with customers on how the additional funds are being spent and to provide on-going status updates on system renewal.

# How Could the Consultation Process be Improved?

At the conclusion of the sessions, participants were asked what they thought of this approach to customer and stakeholder consultation and how it could be improved.

- The vast majority stated they very much liked this approach to customer consultation. They felt the workbook-led format allowed them to have a meaningful discussion on what often is seen as a confusing and complex topic.
- Participants expressly liked the final questions concerning "permission" as they felt the appropriate
  customer opinion measurement in accessing Horizon Utilities' distribution system plan was not
  support, but rather permission. While no one likes to pay more for anything, let alone a commodity
  such as electricity, customers might give Horizon Utilities permission to go ahead with the proposed
  plan if the distributor makes the case that a rate increase is necessary.
- Participants also stated they liked that Horizon Utilities was actively seeking feedback from customers and that they would like to see this approach incorporated into on-going policy decisionmaking.
- Participants had very little to suggest in ways the process could be improved. One suggestion was to perhaps create a video to communicate the themes in the workbook. The video would be shown at the beginning of the consultation session so participants didn't have to read as much.

# Methodology

#### About the Stakeholder and General Service Customer Consultation

INNOVATIVE was engaged by the Horizon Utilities to conduct a series of stakeholder and general service customer consultation sessions designed to identify the needs and preferences of consumers as they relate to the proposed 5-Year DSP.

The consultation sessions were held in St. Catharines on January 14, 2014 and in Hamilton on January 15, 2014. A total of 43 stakeholders and general service customers participated in these consultation sessions.

St. Catharines: January 14, 2014

Community and Industry Stakeholders 5 participants
General Service over 50 kW Rate Class 8 participants
General Service under 50 kW Rate Class 8 participants

Hamilton: January 15, 2014

Community and Industry Stakeholders 8 participants
General Service over 50 kW Rate Class 7 participants
General Service under 50 kW Rate Class 7 participants

Although 12 general service customers were recruited for each consultation session, four to five participants in this category failed to attend each group. This was to be expected given the busy nature of these small and medium sized business owners and managers.

# **Recruiting Consultation Participants:**

Community and industry stakeholders were recruited from a client-provided list. Invited stakeholders represented a diverse range of interests from a cross section of industry, business, environmental and social advocacy groups from both St. Catharines and Hamilton.

General service customers in the under and over 50 kW rate class were randomly selected by telephone from customer lists and screened for appropriateness as session participants. General service customers qualified for the consultation if they managed or oversaw their businesses' electricity bill. This was to ensure they were at least somewhat knowledgeable of their electricity costs and could have an informed discussion on the impact of the proposed rate increases.

Customer recruitment lists were randomly generated and provided to INNOVATIVE by Horizon Utilities.

An incentive of \$100 was provided to all general service customers who participated in the consultation sessions. Community and industry stakeholders did not receive an incentive to participate in the consultation sessions.

All consultation sessions were video recorded to verify participant feedback and quotes.

#### **Consultation Session Structure:**

The consultation sessions were structure around the themes contained in the workbook, which was developed by INNOVATIVE and Horizon Utilities staff in the fall of 2013.

The workbook themes included the following:

- 1. What is this about?
- 2. Electricity Grid 101
- 3. Horizon Utilities' Distribution System Today
- 4. Challenges Facing Our Distribution System
- 5. Controlling Costs
- 6. What Our Plan Means For You
- 7. About Horizon Utilities Corporation

All consultation participants were sent electronic copies of the workbook via email as part of a pre-read package in advance of the sessions.

At the start of the sessions, the facilitator gave an overview explaining the purpose of consultation and why Horizon Utilities is seeking feedback from stakeholder groups and customers.

After explaining the purpose of the consultation, hardcopy workbooks were distributed to act as a session guide for participants to record their answers to the question contained within.

The facilitator then led the participants through the workbook section by section to ensure they understood the information and to answer any questions they had about the content.

When it came to the questions within the workbook, participants were asked to fill in their answers independently. The facilitator then led a group discussion on the answers participants provided and what this meant for their business or constituents.

Hardcopy workbooks were collected from the participants at the conclusion of each consultation session.

Each consultation sessions ran for approximately 2.5 hours.

# **Informing the Consultation Process:**

In addition to identifying customer needs and preferences as they relate to the proposed 5-Year Distribution System Plan, feedback collected from this phase of the consultation was used to inform the design of the telephone survey and used in the subsequent Residential Ratepayer Consultation phase of Horizon Utilities' rate application customer engagement program.

**NOTE:** Results contained within this report are based on a limited sample and should be interpreted as directional only.

# **Participant Feedback**

The following section highlights the general feedback from each consultation group.

#### St. Catharines Consultation Sessions

# Community and Industry Stakeholder Groups (St. Catharines)

# Overall Take-Away

The stakeholders at the consultation represented a diverse range of interests, including consumer advocacy, environmental groups and industry associations. Overall, the stakeholder group agreed with Horizon Utilities proactive approach in investing in new infrastructure in order to maintain service reliability. Several stakeholders stated that the 5 Year Distribution System Plan was necessary and well planned out, but Horizon still had to be mindful of those that would be most impacted by the proposed rate increase (e.g. lower income families and small businesses).

# System Reliability: Customer Experience and Expectation

There was a consensus within the group stating that they have "been impressed by Horizon Utilities and its services". Moreover, they stated that they appreciated the proactive approach Horizon Utilities was taking in getting electrical problems fixed in the St. Catharines area.

Further, some pointed out that the widespread outages were the result of things that happened due to adverse weather and that there was little Horizon Utilities could do prevent such outages.

# Improving Service of the Local Distribution System

The stakeholders stated that depending on the type of business, both frequency of outages and duration of outages can have major consequences. Further, one of the stakeholders representing a business advocacy group recommended that Horizon Utilities give higher priority to "business users" during outages since they employ the community and because such power outages for businesses, relative to residential customers, have greater consequences in terms of an economic impact.

#### System Renewal and Rate Impact

Some of the stakeholders suggested Horizon Utilities take into consideration the economic and social impacts of the price increase, especially during a time of fiscal prudence and economic stagnation within the St. Catharines region.

Some of the stakeholders were worried how the price increase will impact on the average person in St. Catharines. Moreover, they were worried that the rate increase could potentially scare away businesses in the area, causing unemployment rates to rise.

# Coverage of Distribution System Topics

Most of the stakeholders found the workbook to be very informative, providing the group with the right amount of information needed to discuss the issues at hand.

#### How Could the Consultation Process be Improved?

The stakeholders within the group enjoyed the consultation process as they thought it was an effective way to engage people and get them to start talking about electrical distribution issues, which many felt are often taken for granted.

#### General Service over 50 kW Rate Class (St. Catharines)

#### Overall Take-Away

Generally, the participants in this consultation group felt that the proposed 5 Year Distribution System Plan was reasonable, effective, and representative of the electrical power needs of the businesses in the St. Catharines region.

Participants in this session generally agreed with the necessity of a rate increase and thought that it was needed to maintain system reliability. However, some of the participants wanted Horizon Utilities to increase its promotion of conservation demand management programs for businesses to help offset the impact of the proposed rate increase. Further, most of the participants in the group agreed with the proposed rate increase so long as it meant more reliable service for their business.

# System Reliability: Customer Experience and Expectation

Several participants stated that the problem with outages is that they didn't know how long the outages would last. They thought that "better communication is needed from Horizon so that businesses can figure out how to mitigate the impact of power outages."

# Improving Service of the Local Distribution System

Some of the participants stated that a "run-to-failure" approach was only appropriate for residential customers, whereas for business customers, it would be best to replace equipment before it failed as any power service interruption would cost money and have economic consequences.

#### **Coverage of Distribution System Topics**

Overall, the participants thought the workbook was easy to read, well put together, and comprehensive. Further, although out of scope for this consultation, a number of participants would have also liked to see more information in the workbook about renewable energy programs and distributed generation (e.g. solar energy and wind turbines). A number of participants felt that micro-FIT contracts and distributed generation sold back to the grid could help them offset the impact of Horizon Utilities' proposed rate increase.

#### System Renewal and Rate Impact

A few participants questioned the timing of the rate increase, citing it as being too soon for an economy in recovery. They stated that it could have some serious consequences to small businesses and financially struggling firms.

#### How Could the Consultation Process be Improved?

One of the participants felt that consultation on system renewal and capital investing should be an ongoing and regular customer engagement process, as opposed to only part of Horizon Utilities' rate application process.

Moreover, they stated the consultation process made them understand the issues facing the distribution system at a level where they could have a meaningful and informed discussion about system priorities and challenges.

## General Service under 50 kW Rate Class (St. Catharines)

#### Overall Take-Away

Generally participants within this group agreed that the rate increase was necessary to replace aging infrastructure. In particular, some participants felt the 5-Year Distribution System Plan was reasonable as it was not "a quick fix".

However, in exchange for permission for the proposed rate increase, participants also wanted Horizon Utilities to regularly update them on how their money is being spent and the state of the system renewal.

Within this group we also heard about efforts to find efficiency and cut costs in order to shield customers from price increases. While participants in this group were making significant efforts to reduce costs, they had a general sense that Horizon Utilities and other government bodies weren't doing as much as they could to find efficiencies to reduce increased costs passed onto ratepayers and taxpayers alike. They also felt that Horizon Utilities needed to be mindful of the balance between system renewal and custom rate increases: "system renewal must be at a reasonable rate in line with acceptable price increases".

# System Reliability: Customer Experience and Expectation

At one point during the consultation, the facilitator revealed to an unknowing group that the cities of Hamilton and St. Catharines owned Horizon Utilities. The response from participants was that they did not feel like owners, particularly owners who would have any meaningful input.

# Improving Service of the Local Distribution System

A number of participants in the manufacturing sector stated that a rate increase could put them at a competitive disadvantage to firms in the United States and other lower cost jurisdictions. They stated that the comparative advantage they had producing in the region would diminish due to an increase in electricity prices.

Although most participants in the service industry are less likely than manufacturers to feel the impact of an electricity rate increase on their bottom line (i.e. costs would likely be passed onto their customers in businesses where the price elasticity for demand is relatively small), some expressed concern about how passing increased costs onto consumers would impact their sales.

#### Coverage of Distribution System Topics

Most participants in this group felt that the workbook helped them better understand the challenges facing their local distribution system and that a proactive approach to system renewal is better than a reactive one.

While out of scope for this consultation a few participants wanted more information on the other 80% of their electricity bill, outside of their distribution costs.

#### System Renewal and Rate Impact

Most of the group tended to agree that with one participant's comment: "Horizon Utilities has one of the lowest distribution rates in Ontario, and thus the increase in rates is justified".

One of the participants felt that the Horizon Utilities relatively "low rates" were due to inadequate capital investment planning. As a result, customers are now being asked to pay for the aging infrastructure which should have been dealt with years ago.

One of the participants stated that although he does not agree with the proposed rate increase, he thought the "consultation and workbook did an effective job of reminding us how reliant we are on electricity and the vital role it plays for businesses day-to-day operations". Further, the participant went on to state that "If we don't invest in our system and don't accept a price increase, then our electricity system becomes less reliable and will likely end up costing our businesses more money in the long run".

# How Could the Consultation Process be Improved?

Overall, the group thought both the consultation and workbook were effective at presenting the challenges facing their distribution system and what the 5-Year Distribution System Plan entailed.

Most participants initially thought that a price increase would make Horizon Utilities' distribution system more reliable; however, after going through the workbook in detail during the consultation session, they came to realize that the rate increase would only keep the level of reliability consistent, rather than significantly improving the current state of system reliability. This acknowledgement led participants to ask how much it would cost to improve system reliability and why these options were not included in the workbook.

## **Hamilton Consultation Sessions**

# Community and Industry Stakeholder Groups (Hamilton)

#### Overall Take-Away

Like St. Catharines, the stakeholders in this consultation represented a diverse range of interests, including consumer advocacy, environmental groups and industry associations.

Most Hamilton stakeholders felt Horizon Utilities has been fiscally prudent over the past few years and felt that the proposed rate increase was necessary and that the pace of system renewal is just the right amount. Lastly, stakeholders generally felt that the 5-Year Distribution System Plan was well thought out and presented in format that could be relatively easily understood.

# System Reliability: Customer Experience and Expectation

A few stakeholders felt occasionally there was a lack of information and communication between Horizon Utilities and their organizations. However, this was in reference to the recent ice storm that affected Horizon Utilities' service area and the wait times that ensued at the customer service call centre. One participant went on to say that Horizon should have better contingency plans in place during large-scale power service interruptions.

Further, many of the stakeholders felt that Horizon Utilities needs to make sure the system minimizes power service interruptions on the businesses that employ people within the community.

# Improving Service of the Local Distribution System

In terms of communications, a number of stakeholders would like to see better interactive web, mobile and social media tool updates (e.g. customer usage information, assistance and promotion of CDM programs, outage information, etc.)

Although beyond the scope of this consultation, a number of stakeholders felt Horizon Utilities had a responsibility to promote better consumer protection against what was seen as programs (e.g. subproviders).

# Coverage of Distribution System Topics

Some stakeholders felt that there should be a greater emphasis on education, specifically geared towards conservation efforts. These stakeholders felt that in order to educate consumers, Horizon Utilities should partner with social service providers and school boards to promote sustainable energy.

Again, although the stakeholders representing social/poverty advocacy groups generally believed the rate increase was necessary to maintain system reliability, they voiced concern about the impact it would have on people and families living in poverty in the Hamilton region.

#### System Renewal and Rate Impact

Although outside of the scope of this consultation, one stakeholder felt that the Ontario electricity system was a "mess" and he did not fully understand why Horizon Utilities was seeking a rate increase when their revenues were on track. The stakeholder also believed that in order to keep customer cost down, more should be done at the provincial level to reduce waste within the regulatory agencies and crown corporations such as OEB, OPA, IESO, OPG and Hydro One.

A few stakeholders did not like the rate increase as they were not convinced that Horizon Utilities had made efforts to cut costs elsewhere (i.e. the operating budget) or tried to find other efficiencies that could help cover the capital expenditure needed for new infrastructure. However, these same stakeholders ultimately felt the rate increase was necessary.

Although they recognized the need for a rate increase, a number of social advocacy stakeholders were concerned about the lack of programs to assist low-income households and wanted to know if Horizon Utilities would take this into consideration, and if so, how they would help offset the impact.

Others wanted to know how Horizon Utilities planned to deal with a potential increase in demand for the Low-income Energy Assistance Program (LEAP) and other planned measures for residential ratepayers most adversely affected by rate increases.

# How Could the Consultation Process be Improved?

Some of the stakeholders felt that the workbook and consultation focused too much on Horizon Utilities' capital budget and didn't provide enough information on its operating budget. They had hoped that the consultation and workbook would provide more information on Horizon Utilities' operating budget and its efforts to reduce costs.

## General Service over 50 kW Rate Class (Hamilton)

#### Overall Take-Away

Unlike other consultation sessions, general service customer in the over 50 kW rate class in Hamilton were less likely than any other group to accept a rate increase to support Horizon Utilities' 5-Year Plan.

Much of the pushback from this group of customers was largely centered on the perception that Horizon Utilities has not been fiscally prudent over the past years. Many felt that it was irresponsible of Horizon Utilities' management to have not adequately anticipated the investment requirements needed for system renewal. They added that Horizon Utilities should have created a *reserve fund* over the past decade to offset the customer rate increase. As business owners and managers, they explained that in their business they need to put money aside in their budgets to replace aging equipment and tools. Participants in this consultation session could not understand why Horizon Utilities does not have the business acumen to follow similar budget forecasting that is regularly employed by the private sector.

### System Reliability: Customer Experience and Expectation

Some participants felt that communication could be improved between Horizon Utilities and its business customers. They stated that they did not only expect reliable services from their LDC, but also expected that it would communicate more proactively during times of outage. One participant wanted to be notified via text messaging or email as to how long a power service interruption would last and what Horizon Utilities was doing to fix it. However, when participants were asked how they access information on power restoral times during service interruptions, very few knew what channels to go through to retrieve this information from Horizon Utilities.

A number of the participants wanted Horizon Utilities to increase their efforts to help businesses find ways to reduce their electricity consumption to offset the impact of the proposed rate increase.

#### Improving Service of the Local Distribution System

For businesses in the "service" sector, the duration of the outage is more of a problem than the frequency. In contrast, those in the "manufacturing" sector stated that the frequency of outages was more of an issue for them than duration. For manufacturers, their machines and equipment take a significant amount of time to reset with any power interruption, regardless of whether the outage lasts one minute or for four hours.

# **Coverage of Distribution System Topics**

A number of participants wanted to know more about Horizon Utilities operating budget and whether they were able to cut costs or find alternate savings to limit or avoid a rate increase for consumers. Other participants felt Horizon Utilities should be more transparent with how it spends ratepayer money and that such measures would make the distributor more accountable and transparent to customers. When asked about how one would uncover information on Horizon Utilities' operating costs, it was noted that none of the participants have ever sought out the LDC's publicly disclosed financial statements.

## System Renewal and Rate Impact

Some participants felt that the rate increase was unfairly burdened on business customers, which in many cases are struggling in self-described tough economic times. A number of them felt either the local, provincial, or federal government should somehow subsidize the impact of any electricity rate increase to help them remain competitive and create jobs in the local economy.

A few participants stated that their businesses could afford the proposed rate increase, but they were worried about the impact it might have on their suppliers and customers in the local economy (e.g. small business owners and financially struggling firms).

A number of participants in this group felt that Horizon Utilities should have already started saving up capital funds beforehand so that consumers were not suddenly hit by a substantial price increase.

#### General Service under 50 kW Rate Class (Hamilton)

#### Overall Take-Away

While most customers in this group do not like the idea of a price increase over the next 5 years, they generally feel that it's necessary to maintain the reliability of the local distribution system and that Horizon Utilities had presented a compelling case to justify the required investment.

From the perspective of managers and business owners in this session, poor system reliability has a much larger impact to their bottom line than the proposed rate increase.

When given the option, the participants in this consultation session strongly felt that Horizon Utilities should start investing in system renewal now in order to avoid paying even more the longer the rebuild is delayed.

## System Reliability: Customer Experience and Expectation

Many of the participants in this group felt that Horizon Utilities needs to invest and modernize the local electricity system so consumers can have greater control over their electricity usage. These participants also strongly supported the need to invest in new infrastructure and technology to minimize the number and duration of power service interruptions.

Some of the participants believed that the proposed system renewal plan is balanced, as it seeks to maintain reliability while minimizing customer impact. While not universally recognized within the group, proponents of Horizon Utilities' proposed plan understood the trade-off between system reliability and the impact on customer electricity rates.

#### Improving Service of the Local Distribution System

A number of participants felt that Horizon Utilities can improve their customer services by better providing businesses with accessible information on the status of power outages and the length of time it will take to restore it. Participants suggested more timely and accurate web site updates on power service interruptions as well as mobile apps that would provide updates to customer account contacts with service restoration times.

One participant stated that the electricity sector was complicated and confusing; he thought it best to trust the engineers and experts at Horizon Utilities to find the right balance in keeping cost down while making the right investments.

# **Coverage of Distribution System Topics**

A few participants felt that Horizon Utilities was not doing enough thinking "outside of the box" when it came to the future of its distribution system. Some had hope to see more forward thinking ideas that incorporated the use of smart grid technologies and distributed generation —in particular, cogeneration and renewable power generation which could feed back into the electricity distribution system when needed.

# System Renewal and Rate Impact

While most of the small business managers and owners in this group felt that a few power outages throughout the year were tolerable, they worried about the impact power service interruptions have on the local economy, their customers and suppliers.

Some of the participants stated that although it was important to invest in the local distribution system, many consumers would not be able to afford the increase. Thus, it was imperative that Horizon Utilities made efforts to keep costs down.

# **Questionnaire Results**

The following tables are the tabulations of participant feedback to questions in the hardcopy workbooks which were returned at the end of each consultation session.

Reponses to open-ended questions are included in the body text of the previous sections.

Green tallies denote feedback from **St. Catharines** stakeholders and general service customers.

Blue tallies denote feedback from **Hamilton** stakeholders and general service customers.

Numbers in purple denote the sum of both St. Catharines and Hamilton participant feedback tallies

*Missing values* are recorded beneath each table to indicate the number of participants who left a particular question unanswered.

#### 1. Did you experience a power service interruption in the last year?

| Response   | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Yes        | 4                         | 7                   | 6  | 17    | 7                         | 4                   | 7  | 18    | 35    |
| No         | 1                         | 0                   | 2  | 4     | 0                         | 3                   | 0  | 3     | 6     |
| Don't know | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Total      | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

3. If you did experience a power service interruption, how satisfied were you with the way that Horizon Utilities Responded?

| Response             | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|----------------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Very satisfied       | 4                         | 3                   | 3  | 10    | 4                         | 2                   | 3  | 9     | 19    |
| Somewhat satisfied   | 1                         | 2                   | 2  | 5     | 2                         | 1                   | 1  | 4     | 9     |
| Not very satisfied   | 0                         | 0                   | 1  | 1     | 0                         | 0                   | 2  | 2     | 3     |
| Not satisfied at all | 0                         | 0                   | 1  | 1     | 1                         | 1                   | 0  | 2     | 3     |
| Don't know           | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 1  | 1     | 1     |
| Total                | 5                         | 5                   | 7  | 17    | 7                         | 4                   | 7  | 18    | 35    |

Missing values = 8

4. Is Horizon Utilities response to power service interruptions getting better or worse?

| Response        | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|-----------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Much better     | 3                         | 1                   | 1  | 5     | 1                         | 0                   | 3  | 4     | 9     |
| Somewhat better | 1                         | 2                   | 2  | 5     | 1                         | 3                   | 2  | 6     | 11    |
| Somewhat worse  | 0                         | 0                   | 1  | 1     | 2                         | 0                   | 1  | 3     | 4     |
| Much worse      | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Don't know      | 1                         | 3                   | 3  | 7     | 3                         | 1                   | 1  | 5     | 12    |
| Total           | 5                         | 6                   | 7  | 18    | 7                         | 4                   | 7  | 18    | 36    |

Missing values = 7

5. How many power service interruptions are reasonable in a year?

| Response       | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS<br><<br>50<br>Kw | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS<br><<br>50<br>Kw | Total | Count |
|----------------|---------------------------|---------------------|---------------------|-------|---------------------------|---------------------|---------------------|-------|-------|
| None           | 0                         | 0                   | 2                   | 2     | 1                         | 3                   | 1                   | 5     | 7     |
| One            | 1                         | 2                   | 1                   | 4     | 2                         | 1                   | 1                   | 4     | 8     |
| Two            | 3                         | 1                   | 2                   | 6     | 4                         | 2                   | 2                   | 8     | 14    |
| Three          | 0                         | 3                   | 0                   | 3     | 0                         | 1                   | 2                   | 3     | 6     |
| Four           | 1                         | 2                   | 2                   | 5     | 0                         | 0                   | 1                   | 1     | 6     |
| More than four | 0                         | 0                   | 0                   | 0     | 0                         | 0                   | 0                   | 0     | 0     |
| Don't know     | 0                         | 0                   | 0                   | 0     | 0                         | 0                   | 0                   | 0     | 0     |
| Total          | 5                         | 8                   | 7                   | 20    | 7                         | 7                   | 7                   | 21    | 41    |

Missing values = 2

6. What is a reasonable duration for a service interruption?

| Response        | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|-----------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| 0 minutes       | 0                         | 0                   | 1  | 1     | 1                         | 1                   | 0  | 2     | 3     |
| 30 minutes      | 1                         | 2                   | 5  | 8     | 1                         | 5                   | 0  | 6     | 14    |
| 1 hour          | 2                         | 3                   | 1  | 6     | 1                         | 1                   | 4  | 6     | 12    |
| 2 hours         | 1                         | 0                   | 1  | 2     | 3                         | 0                   | 1  | 4     | 6     |
| 3 hours         | 0                         | 1                   | 0  | 1     | 1                         | 0                   | 1  | 2     | 3     |
| 4 hours or more | 0                         | 1                   | 0  | 1     | 0                         | 0                   | 0  | 0     | 1     |
| Don't know      | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Total           | 4                         | 7                   | 8  | 19    | 7                         | 7                   | 6  | 20    | 39    |

Missing values = 4

7. If Horizon Utilities is able to improve the reliability of its distribution system, should they put more focus on reducing the **number** of power service interruptions or reducing the **duration** of service interruptions?

| Response   | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|--|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Focus on reducing the NUMBER of power service interruptions      | 0                         | 1                   | 0  | 1     | 2                         | 2                   | 0  | 4     | 5     |
| Focus on reducing the DURATION of the power service interruption | 2                         | 3                   | 4  | 9     | 2                         | 2                   | 5  | 9     | 18    |
| Both   | 3                         | 3                   | 4  | 10    | 3                         | 3                   | 2  | 8     | 18    |
| Don't know   | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Total  | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

Missing values = 2

8. How satisfied are you with the job Horizon Utilities is doing running your local distribution system?

| Response              | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|-----------------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Very satisfied        | 4                         | 3                   | 2  | 9     | 3                         | 2                   | 5  | 10    | 19    |
| Somewhat satisfied    | 0                         | 5                   | 5  | 10    | 4                         | 4                   | 1  | 9     | 19    |
| Somewhat dissatisfied | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Very dissatisfied     | 0                         | 0                   | 0  | 0     | 0                         | 1                   | 1  | 2     | 2     |
| Don't know            | 0                         | 0                   | 1  | 1     | 0                         | 0                   | 0  | 0     | 1     |
| Total                 | 4                         | 8                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

10. While many utilities follow this practice, others do not. Which of the following best represents your view?

| Response  | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS<br><<br>50<br>Kw | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS <<br>50<br>Kw | Total | Count |
|---|---------------------------|---------------------|---------------------|-------|---------------------------|---------------------|------------------|-------|-------|
| "Running-to-failure" is a good way to get full value from equipment so long as the resulting power service interruption is contained and quickly restored.                    | 3                         | 8                   | 7                   | 18    | 4                         | 4                   | 7                | 15    | 33    |
| Horizon Utilities should ensure reliable power and not wait until equipment fails, even if that means it needs to spend more money replacing equipment that is still working. | 2                         | 0                   | 0                   | 2     | 3                         | 3                   | 0                | 6     | 8     |
| Don't know  | 0                         | 0                   | 0                   | 0     | 0                         | 0                   | 0                | 0     | 0     |
| Total   | 5                         | 8                   | 7                   | 20    | 7                         | 7                   | 7                | 21    | 41    |

Missing values = 2

## 11. Did Horizon Utilities' Distribution System Plan cover the topics you expected?

| Response   | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS<br><<br>50<br>Kw | Total | Community<br>Stakeholders | GS<br>> 50<br>Kw | GS <<br>50<br>Kw | Total | Count |
|------------|---------------------------|---------------------|---------------------|-------|---------------------------|------------------|------------------|-------|-------|
| Yes        | 3                         | 8                   | 7                   | 18    | 4                         | 4                | 7                | 15    | 33    |
| No         | 2                         | 0                   | 0                   | 2     | 3                         | 3                | 0                | 6     | 8     |
| Don't know | 0                         | 0                   | 0                   | 0     | 0                         | 0                | 0                | 0     | 0     |
| Total      | 5                         | 8                   | 7                   | 20    | 7                         | 7                | 7                | 21    | 41    |

12. Do you feel you have a good general sense of how Horizon Utilities' distribution system works?

| Response   | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Yes        | 5                         | 7                   | 8  | 20    | 7                         | 6                   | 6  | 19    | 39    |
| No         | 0                         | 0                   | 0  | 0     | 0                         | 1                   | 0  | 1     | 1     |
| Don't know | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 1  | 1     | 1     |
| Total      | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

Missing values = 2

13. Do you feel you have a good general understanding of the challenges regarding Horizon Utilities' distribution system?

| Response   | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Yes        | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |
| No         | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Don't know | 0                         | 0                   | 0  | 0     | 0                         | 0                   | 0  | 0     | 0     |
| Total      | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

Missing values = 2

14. Considering what you know and have learned about the local distribution system, do you feel the proposed rate of system renewal is ...

| Response    | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|-------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| Too slow    | 0                         | 0                   | 0  | 0     | 1                         | 2                   | 0  | 3     | 3     |
| Too fast    | 1                         | 0                   | 0  | 1     | 1                         | 3                   | 1  | 5     | 6     |
| About right | 4                         | 5                   | 6  | 15    | 5                         | 0                   | 4  | 9     | 24    |
| Don't know  | 0                         | 1                   | 0  | 1     | 0                         | 2                   | 0  | 2     | 3     |
| Total       | 5                         | 6                   | 6  | 17    | 7                         | 7                   | 5  | 19    | 36    |

15. Considering what you know about the local distribution system, which of the following best represents your point of view:

| Response                     | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Community<br>Stakeholders | GS<br>><br>50<br>Kw | GS | Total | Count |
|------------------------------|---------------------------|---------------------|----|-------|---------------------------|---------------------|----|-------|-------|
| The rate increase is         |                           |                     |    |       |                           |                     |    |       | _     |
| reasonable and I support     | 1                         | 1                   | 1  | 3     | 4                         |                     | 1  | 5     | 8     |
| it                           |                           |                     |    |       |                           |                     |    |       |       |
| I don't like it, but I think |                           |                     |    |       |                           |                     |    |       |       |
| the rate increase is         | 3                         | 5                   | 5  | 13    | 3                         | 3                   | 5  | 11    | 24    |
| necessary                    |                           |                     |    |       |                           |                     |    |       |       |
| The rate increase is         |                           |                     |    |       |                           |                     |    |       |       |
| unreasonable and I           | 1                         | 1                   | 1  | 3     | 0                         | 4                   | 1  | 5     | 8     |
| oppose it                    |                           |                     |    |       |                           |                     |    |       |       |
| Don't know                   | 0                         | 0                   | 1  | 1     | 0                         | 0                   | 0  | 0     | 1     |
| Total                        | 5                         | 7                   | 8  | 20    | 7                         | 7                   | 7  | 21    | 41    |

# **Phase 3: Residential Ratepayer Survey**

# **Summary**

The following summary highlights the key findings from a telephone survey of 1,011 Horizon Utilities residential customers conducted in January 2014.

#### **General Satisfaction**

Almost half (46%) of Horizon Utilities' customers claim to be familiar with their local distribution system. Of those who indicated they are familiar, 16% say they are very familiar with the system.

However, when it comes to how customer electricity bills are divided between organizations in the electricity sector, only a third of respondents (34%) say they were familiar with the amount of their electricity bill that is allocated to Horizon Utilities.

Almost 9-in-10 respondents (89%) say they are satisfied with the job Horizon Utilities is doing at running their electricity distribution system.

When asked what Horizon Utilities can do to improve their service, a plurality of respondents (34%) suggested it could lower *electricity prices*. It should be noted that 35% say that *nothing needs to be done to improve Horizon Utilities' service*.

# **System Reliability**

A majority of respondents (52%) experienced at least one extreme weather-related power outage at home. Of those, 43% experienced an outage due to the ice storm while 24% had a service interruption due to the wind storm (15% experienced power service interruptions from both weather events).

In contrast, 35% of respondents experienced a non-weather-related power outage in the last 12 months.

When given a list of options, almost three-quarters of respondents (72%) say that Horizon Utilities should address the <u>number of power outages</u> by either spending what is needed to <u>maintain</u> or <u>reduce</u> the current level of outages. Only 16% say they would accept more power outages in order to keep customer costs down.

Similarly, 73% also say that Horizon Utilities should address the <u>length of power outages</u> by spending what is needed to *maintain* or *reduce* the current length of the outages. Again, only 17% say they would accept longer power outages in order to keep customer costs down.

#### **System Challenges & Priorities**

Regarding investment in aging infrastructure, about 3-in-5 (57%) say that Horizon Utilities should invest what it takes to replace the system's aging infrastructure to lessen the impact of power outages. They say this despite knowing that their bill will increase as a result of the investment.

Concerning investment in new technology, 64% of respondents believe that investments in new technology will increase system reliability, make the local distribution system more efficient and save money in the long run.

Finally, concerning investment in new equipment and tools, 64% support this type of investment. Only about 3-in-10 respondents say that Horizon Utilities should find ways to make do with the buildings and equipment that they have.

#### Overall Assessment of Plan

Almost three-quarters (73%) of respondents in the residential customer survey give Horizon Utilities "permission" for the proposed rate increase – that is, they either think the proposed rate increase is reasonable and support it <u>OR</u> say that they don't like it, but think it is necessary. A quarter of respondents (24%) think the proposed rate increase is unreasonable and oppose it.

| <b>Q</b> : Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view? |     |  |  |  |
|--|-----|--|--|--|
| The proposed rate increase is reasonable and I support it  | 32% |  |  |  |
| I don't like it, but I think the proposed rate increase is necessary   | 41% |  |  |  |
| The proposed rate increase is unreasonable and I oppose it   | 24% |  |  |  |
| Don't know / Refuse  | 3%  |  |  |  |

When asked why they said they would support a rate increase, almost half of respondents (47%) gave the answer because "the improvements are necessary", followed by the "increase is affordable" (42%).

For those who said they don't like the rate increase, but thought it is necessary, the most common reason provided was also that they believe the "improvements are necessary" (32%), followed by "the investment is necessary" (23%).

As for those who think the rate increase is unreasonable, 48% say that it is because "the increase is too high", followed by concerns with both "executive compensation" (13%) and "poor fiscal management at Horizon Utilities" (13%).

# Methodology

This survey was conducted by telephone among 1,011 residential customers of Horizon Utilities, who were randomly selected from a client provided list between January 22<sup>nd</sup> and 29<sup>th</sup>, 2014. A sample of this size is considered accurate to within ±3.1 percentage points, 19 times out of 20. The margin of error will be larger within each sub-grouping of the sample.

# **Questionnaire Design**

The questionnaire was designed to simulate the journey that respondents in the online workbook and Workbook-led Consultation Sessions experienced. This included a combination of educating the customer, having customers reflect on their personal experience with their distribution system, and having them make value judgments on trade-offs between system reliability and bill impact.

As part of simulating the "workbook journey", the questionnaire was informed by and incorporated feedback from the previous phases of Horizon Utilities' customer engagement. This included sharing

both supportive and non-supportive feedback in the survey from previous phases of Horizon Utilities' customer consultation as it related to Horizon Utilities proposed rate increase.

The average survey ran at just under 11 minutes. The survey instrument can be found at the end of this section of the report.

# Fielding the Survey

For the purposes of executing this survey, Horizon Utilities provided INNOVATIVE with a confidential list containing 45,000 of their residential customers' contact information. Horizon Utilities built this contact list by randomly selecting records from among approximately 200,000 residential contact records on file in their customer database.

The contact list included only residential customers with landline contact information on file and who had been a customer of Horizon Utilities since at least December 31<sup>st</sup>, 2012. The information contained in the contact list included customer name, home telephone number, home address, service area, and total annual usage between January 1<sup>st</sup> and December 31<sup>st</sup>, 2013.

Only one customer per household was eligible to complete the survey. Survey respondents were screened to certify that only the resident primarily responsible for paying their Horizon Utilities electricity bill was interviewed. This step was taken to ensure that survey respondents represented the most qualified person within a household to answer questions about their electricity bill and how Horizon Utilities' proposed rate increase would have a relative impact on their bill.

Before retiring any randomly selected telephone number from the contact list, 12 attempts to reach a potential customer for each unique telephone number were initially made, or until an interviewer received a hard refusal. Each number was called twice a day for the first four days and once a day for the final four. Each night – from January 22<sup>nd</sup> to the 29<sup>th</sup> – new sample was released from the contact list to replace completed or retired calls. A target of 125 completes a night was established throughout the course of the fieldwork.

Horizon Utilities' residential customers were contacted at home by telephone between 4pm and 8pm on weekdays; between 10am and 8pm on Saturdays; and between 11am and 8pm on Sundays.

All fieldwork was conducted using INNOVATIVE's CATI system.

# Sample Design

The survey followed a stratified random sampling methodology. This is a method of sampling that involves the division of a population into smaller groups known as strata. In stratified random sampling, the strata are formed based on members' shared attributes or characteristics (in this case, customer service area or electricity usage). A random sample from each stratum is taken in a number proportional to the stratum's size when compared to the customer population. These subsets of the strata are then pooled to form a random sample.

In this survey, residential customers were initially divided into strata based on service area populations. Within service area populations, residential customers were then divided in to quartiles based on annual electricity usage to ensure the sample had a proportionate mix of customers from low, medium-low, medium-high, and high electricity usage households.

The following table illustrates the segmentation of the survey sample by Horizon Utilities' customer service areas.

| Service Area                  | Residential<br>Customers | %      | Target<br>Sample | Actual<br>Sample | Difference |  |
|-------------------------------|--------------------------|--------|------------------|------------------|------------|--|
| Dundas, Flamborough, Ancaster | 16,745                   | 8.0%   | 80               | 83               | +3         |  |
| Hamilton West                 | 18,375                   | 8.8%   | 88               | 89               | +1         |  |
| Hamilton Mountain             | 53,901                   | 25.7%  | 257              | 262              | +5         |  |
| Hamilton Downtown             | 20,723                   | 9.9%   | 99               | 100              | +1         |  |
| Burlington Street Industrial  | 4,880                    | 2.3%   | 23               | 23               | 0          |  |
| Hamilton East                 | 14,451                   | 6.9%   | 69               | 70               | +1         |  |
| Stoney Creek                  | 33,862                   | 16.2%  | 162              | 159              | -3         |  |
| St. Catharines                | 46,620                   | 22.3%  | 223              | 225              | +3         |  |
| TOTAL                         | 209,557                  | 100.0% | 1,000            | 1,011            | +11        |  |

Within service area populations, customers were divided into quartiles based on annual electricity usage. The table below illustrates the actual survey interviews by usage quartile within Horizon Utilities' eight customer service areas.

| <b>Customer Annual Usage Quartiles</b> |  |
|--|--|
|  |  |

| Service Area                  | Low Usage | Medium-Low<br>Usage | Medium-High<br>Usage | High Usage | Total |
|-------------------------------|-----------|---------------------|----------------------|------------|-------|
| Dundas, Flamborough, Ancaster | 21        | 20                  | 21                   | 21         | 83    |
| Hamilton West                 | 23        | 22                  | 22                   | 22         | 89    |
| Hamilton Mountain             | 61        | 68                  | 67                   | 66         | 262   |
| Hamilton Downtown             | 21        | 27                  | 26                   | 26         | 100   |
| Burlington Street Industrial  | 6         | 6                   | 5                    | 6          | 23    |
| Hamilton East                 | 18        | 18                  | 17                   | 17         | 70    |
| Stoney Creek                  | 42        | 33                  | 42                   | 42         | 159   |
| St. Catharines                | 58        | 55                  | 56                   | 56         | 225   |
| TOTAL                         | 250       | 249                 | 256                  | 256        | 1,011 |

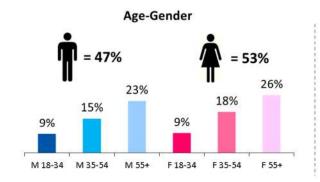
# Sample Weights

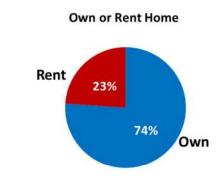
Weights have not been applied as the stratified random sample is an accurate representation of Horizon Utilities' actual customer distribution and type.

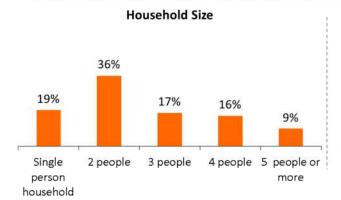
A sample of this size is considered accurate to within ±3.1 percentage points, 19 times out of 20. The margin of error will be larger within each stratum or sub-grouping of the sample.

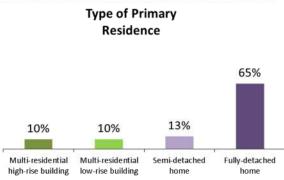
# **Demographic Profile**

The following details the demographic characteristics of respondents who completed the residential ratepayer survey [n=1,011].









# Respondent Feedback

# **General Satisfaction**

This section of the workbook explores experiences with familiarity with the local distribution system and satisfaction with Horizon Utilities in running that system.

## Familiarity with Local Electricity Distribution System

More than 3-in-7 (46%) are familiar with their local distribution system. Of those who indicated they are familiar, 16% say they are very familiar with the system.

- The Dundas, Flamborough, Ancaster Region has the highest level of familiarity with the local system with 54% while Burlington Street Industrial has the lowest degree of familiarity with 35%.
- Differences in consumption level are also related to familiarity. High levels of consumption are associated with high levels of familiarity.
- Respondents who live in single-detached homes are more familiar than those who live in semidetached homes or multi-residential buildings. Those who live in multi-residential buildings over five stories tall have the lowest familiarity levels of all the residence groups.

## Satisfaction with Horizon Utilities Running the Distribution System

89% of respondents are satisfied with the job Horizon Utilities is doing running their electricity distribution system.

- Those living in the Dundas, Flamborough, Ancaster Region and Hamilton West are the most satisfied with Horizon Utilities with 95% and 93% satisfaction rates.
- Those with low levels of consumption have higher levels of satisfaction than those with low consumption rates.
- As for residence type, respondents living in multi-residential buildings are more satisfied with the job Horizon Utilities is doing than their detached-home counterparts.

When asked what Horizon Utilities can do to improve their service, 34% of respondents say that Horizon Utilities could lower its prices. Other answers are: improve customer service, reduce outages and maintain the system. It should be noted that 35% say that nothing needs to be done to improve the service Horizon Utilities provides.

#### Preamble for General Satisfaction Section

Prior to answering the questions in the General Satisfaction Section, respondents were presented with a preamble concerning key components of Ontario's electricity system. The preamble read as follows:

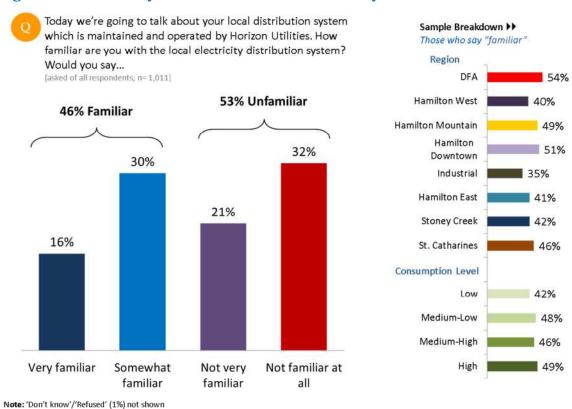
"To start, I'd like to ask you a few questions about the electricity system...

As you may know, Ontario's electricity system has three key components: **generation**, **transmission** and **distribution**.

- **Generating stations** convert various forms of energy into electric power;
- **Transmission lines** connect the power produced at generating stations to where it is needed across the province; and
- Distribution lines carry electricity to the homes and businesses in our communities.

Today we're going to talk about your **local distribution system** which is maintained and operated by Horizon Utilities."

Figure 3.1: Familiarity with the Local Distribution System



Over 45% of respondents are familiar with their local distribution system. Of those who indicated they are familiar, about 1-in-7 (16%) say they are very familiar with the system.

 Across the regions that are served by Horizon Utilities, the Dundas, Flamborough, Ancaster Region (DFA) has the highest level of familiarity with the local system with 54%. Downtown Hamilton follows close behind with a majority of respondents (51%) in the region indicating they are either very or somewhat familiar. In contrast, Burlington Street Industrial has the lowest degree of familiarity with the electricity distribution system at 35%.

- Differences in consumption level are also related to familiarity. High levels of consumption are
  associated with high levels of familiarity. Only 42% of respondents in the low consumption
  group indicate they are familiar with the system. This is in contrast to the 49% of respondents in
  the high consumption group that are at least somewhat familiar with the local electricity
  distribution system.
- Residence type also seems to have an impact on the degree of familiarity with the local
  distribution system. Respondents who live in single-detached homes are more familiar than
  those who live in semi-detached homes or multi-residential buildings. Those who live in multiresidential buildings over five stories tall have the lowest familiarity levels of all the residence
  groups.

Generally speaking, how satisfied are you with the job Horizon Sample Breakdown >> Those who say "satisfied" Utilities is doing running your electricity distribution system? Would you say ... Region [asked of all respondents; n= 1,011] DFA 95% 89% Satisfied Hamilton West Hamilton Mountain 90% 45% 44% Hamilton Downtown Industrial 83% Hamilton East 86% 9% Dissatisfied Stoney Creek 89% St. Catharines 88% Consumption Level Low 92% 5% Medium-Low 4% 91% Medium-High 88% Somewhat Very satisfied Somewhat Very High satisfied dissatisfied dissatisfied

Figure 3.2: Satisfaction with Horizon Utilities' Response

About 9-in-10 respondents are satisfied with the job Horizon Utilities is doing running their electricity distribution system. Of the 89% who are satisfied, 45% said they are very satisfied with the job Horizon Utilities is doing.

- Those living in the DFA Region and Hamilton West are the most satisfied with Horizon Utilities with 95% and 93% satisfaction rates. However, while these two regions have exceptionally high percentages, all regions have satisfaction levels over 80%.
- Consumption levels are also associated with satisfaction. Those with low levels of consumption have higher levels of satisfaction than those with low consumption rates. 92% of respondents

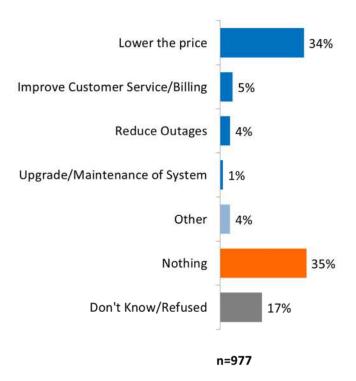
Note: 'Don't know'/'Refused' (2%) not shown

- who indicate low consumption levels are satisfied versus 88% of respondents who have high levels of consumption.
- As for residence type, respondents living in multi-residential buildings are more satisfied with the job Horizon Utilities is doing than their detached home counterparts.89% of respondents living in single-detached homes are satisfied in comparison with the 93% of respondents living in multi-residential buildings over five stories tall that are satisfied.

Figure 3.3: Improvement of Service



Is there anything in particular Horizon Utilities can do to improve their service to you?



A plurality of respondents (34%) says that Horizon Utilities should lower the price when asked what Horizon Utilities can do to improve service. Despite this answer being the most common response, 35% of respondents also say there is nothing Horizon Utilities need to do to improve their service.

The second most common answer given is improve customer service and the billing process (5%), followed by reduce outages (4%) and finally upgrade and provide more maintenance to the distribution system.

# **Electricity Bill Knowledge**

This section explores respondent perceptions and knowledge of their electricity bill. It specifically focuses on the breakdown of the bill and what portion respondents estimate goes to Horizon Utilities.

### Familiarity with Share of Bill Going to Horizon Utilities

Concerning familiarity levels with the breakdown of their electricity bill, 34% of respondents say they are familiar with the amount of their electricity bill that went to Horizon Utilities. In contrast, 65% indicate they are not familiar with how their bill is broken down.

- Respondents living in the DFA Region and Stoney Creek are the most familiar with what share of their bill goes to Horizon Utilities.
- At all consumption levels, there is low knowledge concerning the breakdown of their electricity bill.
- Respondents living in semi-detached homes have the highest degree of familiarity (36%), followed by single-detached homes (34%), multi-residential buildings more than five stories (33%) and finally multi-residential buildings less than five stories (24%).

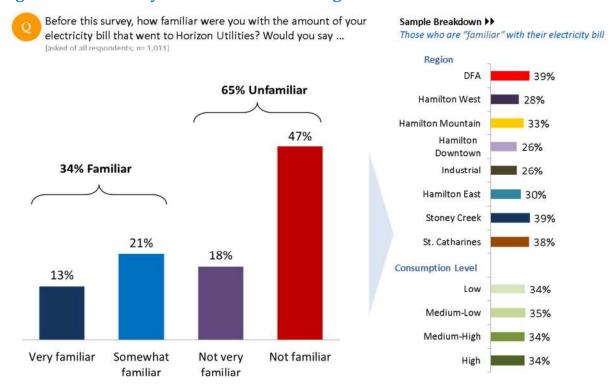
# Preamble for Bill Knowledge & Impact Section

At the start of this section, respondents were presented with a preamble concerning the breakdown of costs of an electricity bill. The preamble read as follows:

"I'd now like to talk with you about your electricity bill...

While some customers pay more and others pay less, the **average residential customer pays about \$135 a month** for electricity of **which \$27 or approximately 20% goes to Horizon Utilities.** The rest of the bill goes to power generation companies, transmission companies, the provincial government and regulatory agencies."

Figure 3.4: Familiarity with Share of Bill Going to Horizon Utilities



Note: 'Don't know'/'Refused' (1%) not shown

Concerning familiarity with the breakdown of their electricity bill, 34% of respondents say they are familiar with the amount of their electricity bill that went to Horizon Utilities. In contrast, over 3-in-5 (65%) indicate they are not familiar with how their bill is broken down.

- Those living in the DFA Region and Stoney Creek are the most familiar with what share of their bill goes to Horizon Utilities. Downtown Hamilton and Industrial appear to have the least amount of knowledge concerning what portion of their bill being distributed to Horizon Utilities.
- There are very few differences between consumption groups. Regardless of consumption levels, there is low knowledge concerning the breakdown of their electricity bill.
- There are differences in levels of familiarity with type of residence. Respondents living in semidetached homes have the highest degree of familiarity (36%), followed by single-detached homes (34%), multi-residential buildings more than five stories (33%) and finally multiresidential buildings less than five stories (24%).

# **System Reliability**

This section covers the feedback provided by respondents on previous power service interruptions, due to weather and non-weather related events. It also discusses perceptions surrounding spending and reducing the number and length of power service interruptions.

## **Power Service Interruptions**

Over half of respondents (52%) experienced at least one power outage due to severe weather. Of those, about 2-in-5 experienced an outage due to the ice storm while a quarter (24%) had a service interruption due to the wind storm. In contrast, 35% respondents experienced a non-weather-related power outage in the last 12 months.

- Those living in the DFA Region were most impacted by storms with 57% indicating they had an
  outage due to an ice storm. In addition, in the same region, 52% indicate that they had an
  outage not due to weather in the last 12 months
- High levels of consumption are associated with higher levels of both weather-related and nonweather-related power outages.
- In the case of weather-related power outages, 54% of single-detached home respondents
  experienced a service interruption in comparison to the 47% of semi-detached respondents who
  experienced an outage. In contrast, for non-weather-related outages, multi-residential
  respondents who live in less than five stories were the most affected with 39% indicating they
  experienced an outage.

# Address Number and Duration of Outages

More than 3-in-7 respondents (46%) say that Horizon Utilities should address the number of power outages by spending what is needed to maintain the current level of outages.

- Around half of respondents living in the DFA Region, Hamilton Mountain and St. Catharines would like to spend what is needed to maintain the current level of outages.
- Half of high level consumers would like to maintain current levels of outages. This is opposed to the 43% of low level consumers who say they want to spend what is needed to reduce the number.
- About 28% of detached home respondents (single and semi-detached) say Horizon Utilities should maintain the current level of outages versus the 24% of multi-residential building respondents (greater and less than five stories) who say the same thing.

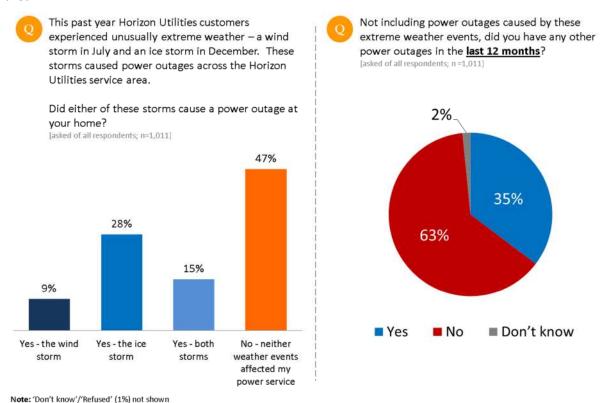
Almost half of respondents (48%) believe that Horizon Utilities should address the length of power outages by spending what is needed to maintain the current length of outages.

- The largest supporter for spending more to reduce the length of power outages is Hamilton Downtown with 32% respondents indicating this is the best option.
- As for consumption level, the only significant difference between groups is between the lowest consumption group and the rest.
- Half of respondents living in single-detached homes support spending what is needed to maintain the current length of outages.

# Figure 3.5: Power Service Interruptions Due to Extreme Weather

Prior to the questions being asked in this section, a preamble concerning power interruptions and extreme weather was provided. The preamble read as follows:

"This past year Horizon Utilities customers experienced unusually extreme weather – a wind storm in July and an ice storm in December. These storms caused power outages across the Horizon Utilities service area."



A majority of respondents experienced at least one power outage due to severe weather. Of those, about 2-in-5 experienced an outage due to the ice storm while a quarter (24%) had a service interruption due to the wind storm. Almost half (47%) did not experience any weather-related power service interruptions.

In contrast, not counting outages due to bad weather, 35% of respondents experienced a power outage in the last 12 months. This means that about 3-in-5 did not experience a non-weather related outage in the last year.

- There is some variation concerning power outages by region. Those living in the DFA Region were most impacted by storms with 57% indicating they had an outage due to an ice storm. The least affected region was Hamilton East. As for outages not due to extreme weather, the DFA Region again was the most highly impacted. Half of respondents (52%) indicate that they had an outage not due to weather in the last 12 months. Hamilton East was least affected with 73% indicating they did not experience an outage.
- There are some differences between different degrees of consumption. High levels of consumption are associated with higher levels of both weather-related and non-weather-related power outages.

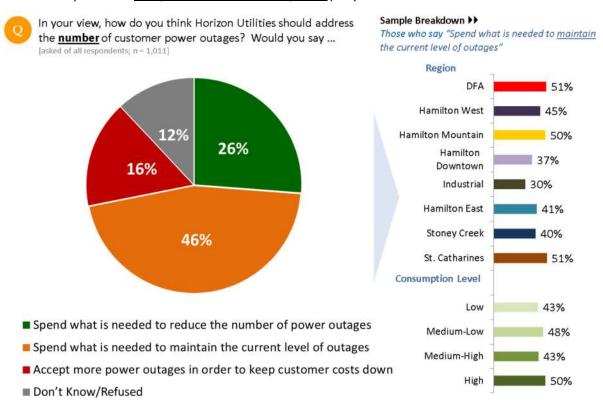
- In the case of weather-related power outages, 54% of single-detached home respondents
  experienced a service interruption in comparison to the 47% semi-detached respondents who
  experienced an outage. Furthermore, 50% of multi-residential less than five stories and 49% of
  multi-residential respondents who live in more than five stories experienced a weather-related
  outage.
- The relationship between housing type and power outages changes slightly when isolating only
  non-weather-related power interruptions. Multi-residential respondents who live in less than
  five stories were the most affected with 39% indicating they experienced an outage. This is
  compared to 37% of single-detached home respondents, 35% of semi-detached home
  respondents and 22% of multi-residential respondents who live in more than five stories.

# Figure 3.6: Address Number of Outages

A preamble concerning the average number of power interruptions was provided before the question concerning addressing the number of outages. The preamble read as follows:

"Despite best efforts, no electrical distribution system can deliver perfectly reliable electricity. The more reliable the system, the more expensive the system is to build and maintain.

With that said –not including **outages caused by extreme weather** – the average Horizon Utilities customer experiences **two power service interruptions** per year."



A plurality of respondents (46%) believe that Horizon Utilities should address the number of power outages by spending what is needed to maintain the current level of outages. This is followed by a

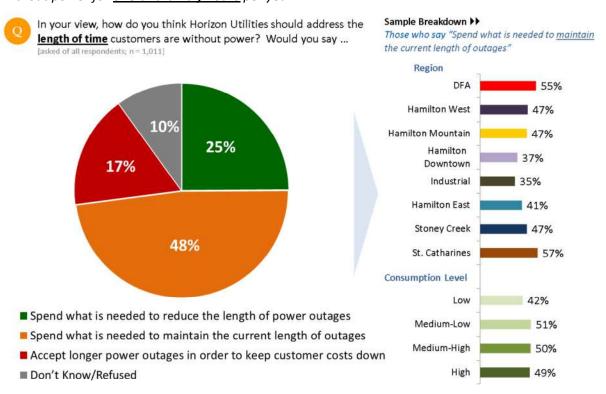
quarter (26%) of respondents who would like Horizon Utilities to spend what is needed to reduce the number of outages.

- Half of respondents living in the DFA Region, Hamilton Mountain and St. Catharines would like
  to spend what is needed to maintain the current level of outages. The largest supporter for
  spending more to reduce the number of power outages is Hamilton Downtown with 32%
  respondents indicating this is the best course of action.
- There are some differences between different degrees of consumption. Half of high level consumers would like to maintain current levels of outages. This is opposed to the 43% of low consumers who say they want to spend what is needed to reduce the number.
- The differences between residence types are most apparent between those who live in detached homes and those who live in multi-residential buildings. About 28% of detached home respondents (single and semi-detached) say Horizon Utilities should maintain current level of outages versus the 24% of multi-residential building respondents (greater and less than five stories) who say the same thing.

# Figure 3.7: Address Duration of Outages

A preamble concerning the average length of power interruptions was provided before the question concerning addressing the duration of outages. The preamble read as follows:

"Again **not including outages caused by extreme weather**, the average Horizon Utilities customer is without power for **one-and-a half hours** per year."



Almost half of respondents (48%) believe that Horizon Utilities should address the length of power outages by spending what is needed to maintain the current length of outages. In contrast, a quarter

(25%) of respondents would like Horizon Utilities to spend what is needed to reduce the length of outages.

- About 3-in-5 respondents in St. Catharines would like to spend what is needed to maintain the
  current length of outages. More than half of respondents living in the DFA Region think the
  current length of outages should be maintained. The largest supporter for spending more to
  reduce the length of power outages is Hamilton Downtown with 32% respondents indicating this
  is the best option.
- As for consumption level, the only significant difference between groups is between the lowest consumption group and the rest. Only 42% of respondents in the low consumption group say they would like to maintain the current length of outages. Around half of each of the other consumption groups says the same. There is no relationship between consumption level and spending more to reduce the length of power outages. A quarter of respondents from each consumption level support spending more.
- Half of respondents living in single-detached homes support spending what is needed to
  maintain the current length of outages. This is followed by the 44% of semi-detached home
  respondents and 44% of multi-residential building respondents living in more than five stories
  who say the same. Finally, only 2-in-5 multi-residential respondents who live in less than five
  stories indicate they would spend what is needed to maintain the current length of outages.

# **System Challenges & Priorities**

This section explores respondents' support for various types of investment including infrastructure, technology and tools and equipment.

# **Investment in Aging Infrastructure**

Concerning investment in aging infrastructure, 57% or respondents believe that Horizon Utilities should invest what it takes to replace the system's aging infrastructure to lessen the impact of power outages. They support this even if it means their bill will increase.

- The DFA Region has the highest level of support for spending what is necessary to fix aging infrastructure.
- The lowest support for investment is from respondents who fall in the high consumption level group. However, more than half of those respondents (54%) still support improving aging infrastructure

### **Investment in New Technologies**

64% of respondents believe that investments in new technology will increase system reliability, make the local distribution system more efficient and save money in the long run. Only about a quarter of respondents (28%) think that investments in new technology are more of a luxury than a necessity.

- The largest supporter of investment in new technology is Hamilton West with three-quarters of respondents (74%) agreeing that new technology will increase reliability and save money
- There is very little difference in support for new technology across the various levels of consumption and across residence types.

## **Investment in Equipment and Tools**

About 3-in-5respondents (64%) believe that Horizon Utilities should be wise with its spending but they also think it is important that its staff have the equipment and tools they need to manage the system efficiently and reliably.

- Across the regions, the largest supporter of investment in equipment and tools is Hamilton West with 70% of respondents agreeing that the investment is important.
- The medium-low consumption level is associated with the highest degree of support for investment in new tools and equipment.
- The highest degree of support for investment in equipment and tools across residence type is from multi-residential building respondents who live in more than five stories. About 7-in-10 respondents say they would support this type of investment.

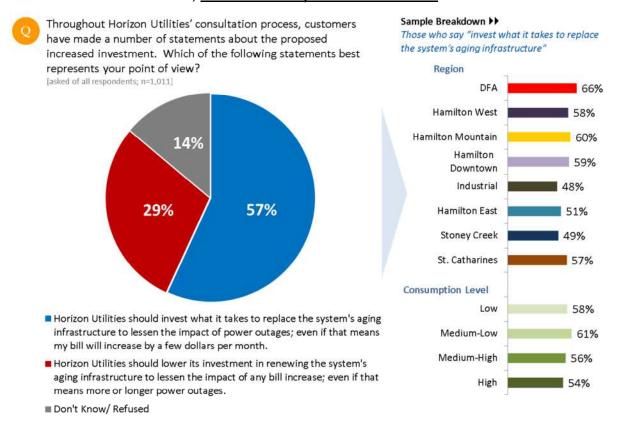
# Figure 3.8: Investment in Aging Infrastructure

A preamble concerning Horizon Utilities' aging infrastructure was provided before the question regarding investment in aging infrastructure. The preamble read as follows:

"As you may be aware, much of your local electricity system is aging and needs to be replaced in the near future. The time lost to power service interruptions caused by aging equipment has been growing steadily over the past decade.

An independent engineering firm that analyzed the health of the Horizon Utilities' electricity system has identified a 20-year investment need of **approximately \$700 million**.

As part of its 5-year plan, Horizon Utilities is proposing to increase its annual infrastructure renewal investment from \$17 million today to \$35 million by 2019. Although this plan will allow Horizon to meet the recommended investments, it will have an impact on customer bills."

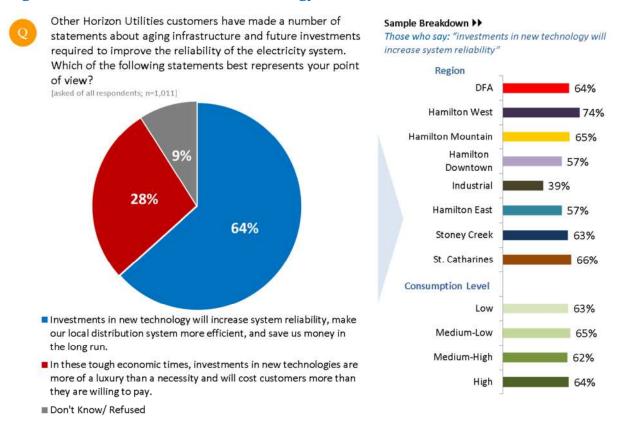


About 3-in-5 (57%) believe that Horizon Utilities should invest what it takes to replace the system's aging infrastructure to lessen the impact of power outages. They agree to this even if it means their bill will increase. In contrast, 29% of respondents think Horizon Utilities should lower its investment in renewing the system's aging infrastructure even if it means there will be more or longer outages.

- 2-in-3 respondents living in the DFA Region think that Horizon Utilities should invest in what it takes to replace aging infrastructure. The next strongest supporters for this type of investment come from Hamilton Mountain (60%) and Hamilton Downtown (59%).
- There are some differences in consumption level regarding support for investment in aging infrastructure. The lowest support for investment is from respondents who fall in the high

- consumption level group. However, more than half (54%) of those respondents still support improving aging infrastructure. Overall, the highest degree of support for investment is from the medium-low consumers where more than 60% say Horizon should invest in infrastructure.
- There are no substantial differences across residence type for supporting investment in aging infrastructure.

Figure 3.9: Investment in New Technology



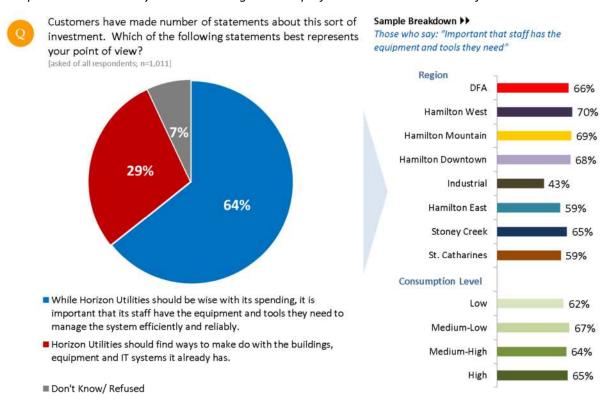
More than 3-in-5 respondents (64%) believe that investments in new technology will increase system reliability, make the local distribution system more efficient and save money in the long run. Only about a quarter of respondents (28%) think that investments in new technology are more of a luxury than a necessity.

- Across the regions, the largest supporter of investment in new technology is Hamilton West with three-quarters of respondents (74%) agreeing that new technology will increase reliability and save money. The lowest level of agreement is in Industrial where only 39% of respondents agree that Horizon should make the investment.
- There is little difference in support for new technology across the various levels of consumption.
- There is also no substantial difference across residence type for supporting investment in new technology.

#### Figure 3.10: Investment in Equipment and Tools

Prior to the question concerning investment in equipment and tools, a preamble concerning the importance of housing, vehicles and tools was provided. The preamble read as follows:

"Horizon Utilities is not just the local electricity distribution system itself, but the business that operates the system. As a business, Horizon Utilities needs buildings to house its staff, vehicles and tools to service the power lines and IT systems to manage service performance and customer information."



More than 3-in-5 respondents believe that Horizon Utilities should be wise with its spending but they also think it is important that its staff have the equipment and tools they need to manage the system efficiently and reliably.

- Across the regions, the largest supporter of investment in equipment and tools is Hamilton West with 70% of respondents agreeing that it is important that Horizon Utilities' staff have the equipment and tools they need to manage the system.
- The medium-low consumption level is associated with the highest degree of support for investment in new tools and equipment. It is followed closely by support from the high consumption level, the medium-high level and finally support from the low consumption level.
- The highest degree of support for investment in equipment and tools across residence type is from multi-residential building respondents who live in more than five stories. About 7-in-10 respondents say they would support this type of investment. This is followed by single-detached homes (65%), semi-detached homes (63%) and multi-residential buildings with less than five stories (62%).

#### **Reaction to Previous Customer Consultation Input**

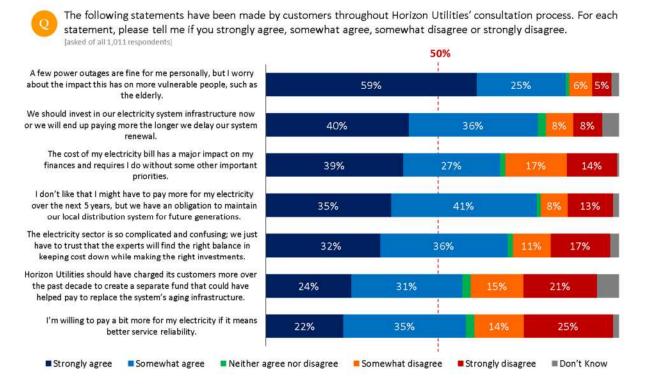
This section measures agreement with some of the key opinion statements provided by Horizon Utilities' customers. This allows us to accurately capture public opinion on electricity costs and the effects of power outages on individuals.

#### **Customer Reaction Statements**

Of the seven customer input statements provided in the questionnaire, the statement with the most support is "a few power outages are fine for me personally, but I worry about the impact this has on more vulnerable people, such as the elderly".

The statement with the lowest level of agreement is "Horizon Utilities should have charged its customers more over the past decade to create a separate fund that could have helped pay to replace the system's aging infrastructure".

#### Figure 3.11: Customer Input Statements



A majority of respondents agree with all of the customer input statements provided in the questionnaire. Of all the phrases that were given, the statement with the most support is "a few power outages are fine for me personally, but I worry about the impact this has on more vulnerable people, such as the elderly". Over 4-in-5 respondents (84%) indicate that they either somewhat agree or strongly agree with this statement.

The statement with the lowest level of agreement is "Horizon Utilities should have charged its customers more over the past decade to create a separate fund that could have helped pay to replace the system's aging infrastructure". This statement also has the second highest level of disagreement. However, the most disagreeable statement with 39% of respondents saying they either somewhat

disagree or strongly disagree is "I'm willing to pay a bit more for my electricity if it means better service reliability".

#### **Assessment of Plan**

This section explores the degree of permission that Horizon Utilities' customers have for a rate increase. Permission is defined as either support for a rate increase or agreeing that is necessary. This section also explores the underlying reasons for permission and opposition to a rate increase.

#### **Permission for Rate Increase**

About three-quarters of respondents (73%) give permission for the proposed rate increase. Only a quarter of respondents (24%) think the rate increase is unreasonable.

- The highest rate of permission comes from the DFA Region. In this region, 4-in-5 respondents give Horizon Utilities permission for the proposed rate increase.
- Respondents with the lowest consumption level show the lowest percentage of permission (70%) and the medium-low consumption group showing the highest percentage of permission with 76%.
- Respondents from multi-residential buildings less than five stories and respondents from singledetached homes are most likely to give permission for the rate increase.

Almost half of respondents (47%) gave the answer "the improvements are necessary" when asked why they said they would support a rate increase.

For those who said they don't like the rate increase but they think it is necessary, the most common reason provided is also that "the improvements are necessary".

Half of the respondents who said that the rate increase is unreasonable and opposed it say that it is because "the increase is too high".

#### Preamble for Assessment of Plan Section

Prior to the questions given in the Assessment of Plan Section, respondents were presented with a preamble concerning the breakdown of pricing for Horizon Utilities' 5-year plan. The preamble read as follows:

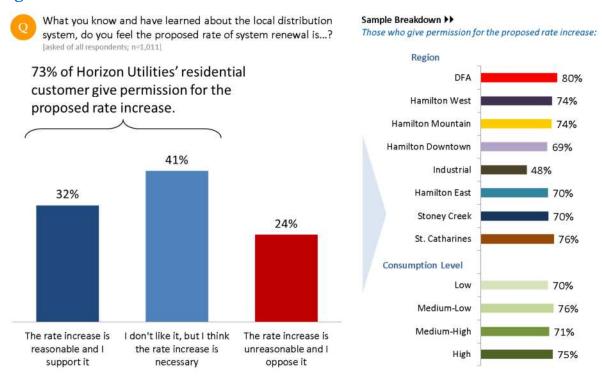
"To maintain the reliability of the local electricity system, Horizon Utilities' proposed 5-year plan will cost an estimated **\$228 million**. This includes...

- \$147 million to replace aging infrastructure;
- \$41 million to maintain metering and connect new customers to the electricity system;
- **\$31 million** to invest in tools, computers and software systems, vehicles and facilities needed to manage the electricity system; and
- \$9 million for new technologies to make the system more efficient and reliable.

To help pay for this plan, Horizon Utilities is proposing the **average residential customers' rate increase by 4.2%** on the distribution portion of their bill for the next five years.

That works out to an average annual increase of **approximately \$1.12 a month**, each year. As such, by 2019, the average residential household will be paying an **estimated \$5.60** <u>more</u> per month on their distribution portion of their electricity bill."

Figure 3.12: Permission for Rate Increase

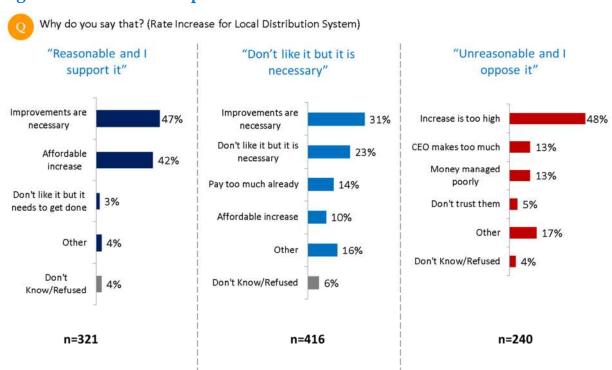


Note: 'Don't know'/'Refused' (3%) not shown

Three-quarters of respondents (73%) give permission for the proposed rate increase. Permission is the combination of respondents who either support the rate increase or those who don't like it but think that it is necessary. Only a quarter of respondents (24%) think the rate increase is unreasonable.

- Across the regions, there is variation in the percentage of respondents who give permission to
  Horizon Utilities. The highest rate of permission comes from the DFA Region where 4-in-5
  respondents give Horizon Utilities permission for the proposed rate increase. The second
  strongest supporter is St. Catharines with 76% of respondents saying that the rate increase is
  reasonable or it is necessary.
- There is some variation across consumption level. Respondents with the lowest consumption level show the lowest percentage of permission with 70% while the medium-low consumption group shows the highest percentage of permission with 76%.
- There are some substantial differences between different residence types. Respondents from
  multi-residential buildings less than five stories and respondents from single-detached homes
  are most likely to give permission for the rate increase, 76% and 75% respectively. The highest
  degree of opposition is from multi-residential building respondents who live in five stories or
  more. Only 69% give permission for the rate increase and 3-in-10 respondents oppose it.

Figure 3.13: Reasons for Opinion on Rate Increase



The top reason provided by those who agreed that the proposed rate is reasonable is that "the improvements are necessary". Almost half of respondents (47%) provided this answer. With 42%, the second most common reason given for supporting the rate increase is that "the increase is affordable".

For those who said they don't like the rate increase but they think it is necessary, the most common reason provided is also that "the improvements are necessary". The second most common answer with about a quarter of the respondents (23%) is that "they don't like it but they realize it is necessary". Other reasons given are that "they pay too much already" (14%) and that "it is an affordable increase" (10%).

Half of the respondents who said that the rate increase is unreasonable and opposed it say that it is because "the increase is too high". The next most common answers each have a significantly lower percentage (13%) than the first most common response. The reasons are that "the CEO makes too much money" and that "the money is managed poorly by Horizon Utilities".

#### **Survey Instrument**

#### **Section A: Introduction**

Hello, my name is \_\_\_\_\_ and I'm calling from **Innovative Research Group** on behalf of **Horizon Utilities**, your local utility for electricity.

Innovative Research Group is a national public opinion research firm. We have been commissioned by **Horizon Utilities** to help them better understand the needs and preferences of customers who are responsible for paying their household's electricity bill.

**Horizon Utilities** – which distributes electricity to customers in Hamilton and St. Catharines – is in the process of developing its 5-year distribution system plan and wants to hear from their customers to help inform this plan.

A1. Would you mind if I had ten minutes of your time to ask you some questions? All your responses will be kept strictly confidential.

Yes 1 [continue]
No – NOT PRIMARY BILL PAYER 2 [go to TRANSFER-1]
No – BAD TIME 3 ARRANGE CALLBACK
No – HARD REFUSAL 4 [Terminate]

#### **MONIT**

This call may be monitored or audio taped for quality control and evaluation purposes.

PRESS TO CONTINUE 1

A2. Have I reached you at your home phone number?

#### **INTERVIEWER NOTE; IF "NO" ASK:** May I speak to someone who does live there?

Yes - SPEAKING, CONTINUE

YES - TRANSFERRED - (GO BACK TO INTRODUCTION)

No - NOT AVAILABLE - (ARRANGE CALLBACK)

Refused - LOG (THANK AND TERMINATE)

1 [continue to A3]

2 [back to INTRO]

ARRANGE CALLBACK]

A3. Are you the person primarily responsible for paying the electricity bill in your household?

Yes 1 [continue to A4]
No 2 [go to TRANSFER-1]
Don't know (DNR) 98 [Terminate]

#### **TRANSFER-1**

Can I speak with the person in your household who usually pays the electricity bill?

Yes 1 [BACK TO INTRO]
No - NOT AVAILABLE/BAD TIME - (ARRANGE CALLBACK) 2 [ARRANGE CALLBACK]
No - HARD REFUSAL 3 [Terminate]
Don't know (DNR) 98 [Terminate]

A4. Can you confirm that your household receives an electricity bill from Horizon Utilities?

Yes1[continue]No2[Terminate]Don't know (DNR)98[Terminate]

**GENDER** Note gender by observation:

Male 1 Female 2

#### **Section B: General Satisfaction**

#### B5. PREAMBLE-1

To start, I'd like to ask you a few questions about the electricity system ...

As you may know, Ontario's electricity system has three key components: **generation**, **transmission** and **distribution**.

- **Generating stations** convert various forms of energy into electric power;
- **Transmission lines** connect the power produced at generating stations to where it is needed across the province; and
- **Distribution lines** carry electricity to the homes and businesses in our communities.

Today we're going to talk about your **local distribution system** which is maintained and operated by **Horizon Utilities**.

How familiar are you with the **local electricity distribution system**? Would you say ... [READ LIST]

| Very familiar       | 1  |
|---------------------|----|
| Somewhat familiar   | 2  |
| Not very familiar   | 3  |
| Not familiar at all | 4  |
| Don't know (DNR)    | 98 |
| Refused (DNR)       | 99 |

B6. Generally speaking, how satisfied are you with the job Horizon Utilities is doing running your electricity distribution system? Would you say ... [READ LIST]

| Somewhat satisfied 2        |   |
|-----------------------------|---|
| Somewhat dissatisfied 3     |   |
| Very dissatisfied 4         |   |
| Don't know ( <b>DNR</b> ) 9 | 8 |
| Refused ( <b>DNR</b> ) 9    | 9 |

B7. Is there anything in particular Horizon Utilities can do to improve their service to you?

[OPEN]

Don't know (**DNR**) 98 Refused (**DNR**) 99

#### **Section C: Bill Knowledge**

I'd now like to talk with you about your electricity bill ...

C8. While some customers pay more and other pay less, the average residential customer pays about \$135 a month for electricity of which \$27 or approximately 20% goes to Horizon Utilities. The rest of the bill goes to power generation companies, transmission companies, the provincial government and regulatory agencies.

Before this survey, how familiar were you with the amount of your electricity bill that went to Horizon Utilities? Would you say ... [READ LIST]

| Very familiar             | 1  |
|---------------------------|----|
| Somewhat familiar         | 2  |
| Not very familiar         | 3  |
| Not familiar              | 4  |
| Don't know ( <b>DNR</b> ) | 98 |
| Refused (DNR)             | 99 |

#### **Section D: System Reliability**

D9. This past year Horizon Utilities customer experienced unusually extreme weather – a wind storm in July and an ice storm in December. These storms caused power outages across the Horizon Utilities service area.

Did either of these storms cause a power outage at your home?

#### **INTERVIEWER NOTE:** Make sure respondents specify which storm affected their power.

| Yes – the wind storm                                  | 1  |
|---|----|
| Yes – the ice storm                                   | 2  |
| Yes – both storms                                     | 3  |
| No – neither weather events affected my power service | 4  |
| Don't know (DNR)                                      | 98 |
| Refused (DNR)   | 99 |

#### [Ask all respondents]

D10. Not including power outages caused by these extreme weather events, did you have any other power outages in the last 12 months?

| Yes              | 1  |
|------------------|----|
| No               | 2  |
| Don't know (DNR) | 98 |
| Refused (DNR)    | 99 |

#### Ask all respondents

D11. Despite best efforts, no electrical distribution system can deliver perfectly reliable electricity. The more reliable the system, the more expensive the system is to build and maintain.

With that said –not including outages caused by extreme weather – the average Horizon Utilities customer experiences two power service interruptions per year.

In your view, how do you think Horizon Utilities should address the number of customer power outages? Would you say ... [READ LIST]

#### [Rotate response code 1 and 3]

| Spend what is needed to reduce the number of power outages            | 1  |
|---|----|
| Spend what is needed to maintain the current level of outages         | 2  |
| Accept <b>more</b> power outages in order to keep customer costs down | 3  |
| Don't Know (DNR)  | 98 |
| Refused (DNR)   | 99 |

D12. Again, not including outages caused by extreme weather, the average Horizon Utilities customer is without power for one-and-a-half hours per year.

In your view, how do you think Horizon Utilities should address the length of time customers are without power? Would you say ... [READ LIST]

#### [Rotate response code 1 and 3]

| Spend what is needed to reduce the length of power outages              | 1  |
|---|----|
| Spend what is needed to maintain the current length of power outages    | 2  |
| Accept <b>longer</b> power outages in order to keep customer costs down | 3  |
| Don't Know (DNR)  | 98 |
| Refused (DNR)   | 99 |

#### **Section E: System Challenges & Priorities**

E13. As you may be aware, much of your local electricity system is aging and needs to be replaced in the near future. The time lost to power service interruptions **caused by aging equipment** has been growing steadily over the past decade.

An independent engineering firm that analyzed the health of the Horizon Utilities' electricity system has identified a 20-year investment need of **approximately \$700 million**.

As part of its 5-year plan, Horizon Utilities is proposing to increase its annual infrastructure renewal investment from **\$17 million today to \$35 million by 2019**. Although this plan will allow Horizon to meet the recommended investments, **it will have an impact on customer bills**.

[Read and Rotate statements 1 and 2]

Some customers have said ...

Horizon Utilities should invest what it takes to replace the system's aging infrastructure to lessen the impact of power outages; even if that means my electricity bill will increase by a few dollars per month.

#### Others have said ...

Horizon Utilities should lower its investment in renewing the system's aging infrastructure to lessen the impact of any bill increase; even if that means more or longer power outages.

2

Don't know (**DNR**) 98 Refused (**DNR**) 99

E14. Other Horizon Utilities customers have made a number of statements about aging infrastructure and future investments required to improve the reliability of the electricity system. Which of the following statements best represents your point of view?

[Read and Rotate statements 1 and 2]

#### Some customers have said...

In these tough economic times, investments in new technologies are more of a luxury than a necessity and will cost customers more than they are willing to pay.

#### Others have said ...

Investments in new technology will increase system reliability, make our local distribution system more efficient, and save us money in the long run.

Don't know (**DNR**) 98 Refused (**DNR**) 99 E15. Horizon Utilities is not just the local electricity distribution system itself, but the business that operates the system. As a business, Horizon Utilities needs buildings to house its staff, vehicles and tools to service the power lines and IT systems to manage service performance and customer information.

Again, customers have made number of statements about this sort of investment. Which of the following statements best represents your point of view?

[Read and Rotate statements 1 and 2]

#### Some customers have said ...

Horizon Utilities should find ways to make do with the buildings, equipment and IT systems it already has.

#### Others have said ...

While Horizon Utilities should be wise with its spending, it is important that its staff have the equipment and tools they need to manage the system efficiently and reliably. 2

| Don't know ( <b>DNR</b> ) | 98 |
|---------------------------|----|
| Refused (DNR)             | 99 |

#### **Section F: Reaction to Customer Consultation Input**

The following statements have been made by customers throughout Horizon Utilities' consultation process.

For each statement, please tell me if you strongly agree, somewhat agree, somewhat disagree or strongly disagree.

| Strongly agree                   | 1  |
|----------------------------------|----|
| Somewhat agree                   | 2  |
| Neither agree nor disagree (DNR) | 3  |
| Somewhat disagree                | 4  |
| Strongly disagree                | 5  |
| Don't Know (DNR)                 | 98 |
| Refused (DNR)                    | 99 |
|                                  |    |

#### **RANDOMIZE QUESTIONS**

- F16. The cost of my electricity bill has a major impact on my finances and requires I do without some other important priorities.
- F17. I'm willing to pay a bit more for my electricity if it means better service reliability.
- F18. We should invest in our electricity system infrastructure now or we will end up paying more the longer we delay our system renewal.
- F19. The electricity sector is so complicated and confusing; we just have to trust that the experts will find the right balance in keeping cost down while making the right investments.
- F20. A few power outages are fine for me personally, but I worry about the impact this has on more vulnerable people, such as the elderly.

- F21. Horizon Utilities should have charged its customers more over the past decade to create a separate fund that could have helped pay to replace the system's aging electrical infrastructure.
- F22. I don't like that I might have to pay more for my electricity over the next 5 years, but we have an obligation to maintain the reliability of our local distribution system for future generations.

#### **END BATTERY**

#### Section G: Overall Assessment of Plan

#### G23. PREAMBLE

To maintain the reliability of the local electricity system, Horizon Utilities' proposed 5 year plan will cost an estimated **\$228 million**. This includes ...

- \$147 million to replace aging infrastructure;
- \$41 million to maintain metering and connect new customers to the electricity system;
- \$31 million to invest in tools, computers and software systems, vehicles and facilities needed to manage the electricity system; and
- \$9 million for new technologies to make the system more efficient and reliable.

To help pay for this plan, Horizon Utilities is proposing the **average residential customers' rate increase by 4.2%** on the distribution portion of their bill for the next five years.

That works out to an average annual increase of **approximately \$1.12 a month**, each year. As such, by 2019, the average residential household will be paying an **estimated \$5.60 more per month** on their distribution portion of their electricity bill.

G24. Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view?

#### Rotate response codes 1 and 3

| The proposed rate increase is reasonable and I support it            | 1 |
|--|---|
| I don't like it, but I think the proposed rate increase is necessary | 2 |
| The proposed rate increase is unreasonable and I oppose it           | 3 |
| Don't know ( <b>DNR</b> )  | 8 |
| Refused (DNR)  | 9 |

#### Ask only if G24 = 1, 2, or 3

G25. And why do you say that? [OPEN]

| Don't know (DNR) | 98 |
|------------------|----|
| Refused (DNR)    | 99 |

#### **Section H: Demographics**

These last few questions are for statistical purposes only and we remind you again that all of your responses are completely confidential.

H26. In which year were you born? [Enter YEAR]

#### INTERVIEWER NOTE: if REFUSE; ask "AGE".

| AGE: | Can you tell r | ne what age c | ategory do you | fall into? [ | READ | LIST |
|------|----------------|---------------|----------------|--------------|------|------|
|------|----------------|---------------|----------------|--------------|------|------|

| Less than 18      | 0  |
|-------------------|----|
| 18-25             | 1  |
| 25-34             | 2  |
| 35-44             | 3  |
| 45-54             | 4  |
| 55-64             | 5  |
| 65 years or older | 6  |
| Refused (DNR)     | 99 |

#### H27. Do you own or rent your home?

| Own           | 1  |
|---------------|----|
| Rent          | 2  |
| Refused (DNR) | 99 |

H28. How would you describe your primary residence? Would you say you live in ... [READ LIST]

```
A fully-detached home; 1
A semi-detached home; 2
An apartment or condo building less than 5 stories; or 3
An apartment or condo building 5 stories or higher? 4
Refused (DNR) 99
```

H29. Counting yourself, how many people live in your household?

| 1 person               | 1 SKIP TO END               |
|------------------------|-----------------------------|
| Enter number of people | 27                          |
| 8 or more              | 8                           |
| Refused (DNR)          | 99 <mark>SKIP TO END</mark> |

#### Ask only if H29 = 2 thru 8

H30. And how many of them are under 18?

| None                     | 0  |
|--------------------------|----|
| Enter number of children | 17 |
| 8 or more                | 8  |
| Refused ( <b>DNR</b> )   | 99 |

#### Thank you very much for taking the time to complete this survey.

#### **Phase 4: Key Account Validation Interviews**

#### **Summary**

INNOVATIVE conducted followed-up interviews with 9 of 12 key account customers<sup>4</sup> who participated in one-on-one consultation sessions with Horizon Utilities staff. The interviews were designed to validate the process and to verify that Horizon Utilities provided these customers with the information they needed to provide informed feedback on the proposed plan. The following summary highlights key findings from the validation interviews.

#### Assessment of Plan

Generally, key account customers both liked and agreed with the new cost of service plan laid out in Horizon Utilities' proposed Distribution System Plan, as it meant a more equitable price for Key Accounts. A number of Key Accounts felt that Horizon Utilities' previous Cost of Service approach was disadvantage to them as they were unfairly burdened to pay for distribution costs that they did not fully use and thus felt they were being charged extra to cover the costs of smaller rate classes (i.e. residential and general service users).

#### **Coverage of Distribution System Topics**

All of the 9 Key Accounts believed that Horizon Utilities' Distribution System Plan covered the key areas they expected (e.g. distribution lines, rate change, system renewal, system access, system service, and general plant issues).

#### System Renewal and Rate Impact

Overall, considering what they know about the local distribution system, 5 out of the 9 Key Accounts interviewed believed that the rate *change* is reasonable and they support it. One of the Key Accounts interviewed stated that he does not like the rate change, but thinks it is necessary. Lastly, 3 of the 9 Key Accounts believe that the proposed rate change is unreasonable and therefore oppose it.

Based on what you know and have heard today about Horizon Utilities' plan, which of the following best represents your point of view? [based on 9 responses]

The proposed rate change is reasonable and I support it n=5 I don't like it, but I think the proposed rate change is necessary n=1 The proposed rate change is unreasonable and I oppose it n=3

#### How Could the Consultation Process be Improved?

 $^{4}$  Key accounts are large consumers whose average monthly peak demand is greater than 5 MW.

Overall, all of the Key Accounts thought that the one-on-one interview carried out by Horizon Utilities staff were "professional", "educational", and "candid". They thought that they were able to share and express their own perspectives and views effectively and openly with the Horizon Utilities staff.

Lastly, during the interviews, participants were asked what they thought of this approach to customer consultation and how it could be improved. All of the Key Accounts stated that they liked this approach to customer consultation. They felt this type of interview format allowed them to have a meaningful discussion.

#### Methodology

#### **Key Account Validation Interviews**

Innovative Research Group (INNOVATIVE) was engaged by Horizon Utilities to conduct a series of validation phone calls with key account customers. Key account customers were consulted on the proposed 5 Year Distribution System Plan by Horizon Utilities staff. INNOVATIVE followed-up by telephone with Key Accounts after their consultation session to validate the process and to verify that Horizon Utilities provided these customers with the information they needed to provide informed feedback on the proposed plan.

The initial Horizon Utilities interviews were held from November 27, 2013 until February 4, 2014. A total of 12 Key Accounts participated in these consultation sessions. INNOVATIVE followed up with 9 of the 12 Key Accounts interviewed. The 3 remaining Key Accounts were either unavailable for a follow-up interview or did not respond to INNOVATIVE'S request for an interview.

**NOTE:** Results contained within this report are based on a limited sample and should be interpreted as directional only.

#### **Recruiting Key Account Participants**

The key account participants were recruited from a client-provided list. The Key Accounts represented a diverse range of interests from cross section of manufacturing industry leaders, the healthcare sector, and school-boards. The 9 larger users who completed the validation interviews with INNOVATIVE were promised confidentiality. As such, they have remained anonymous in this report.

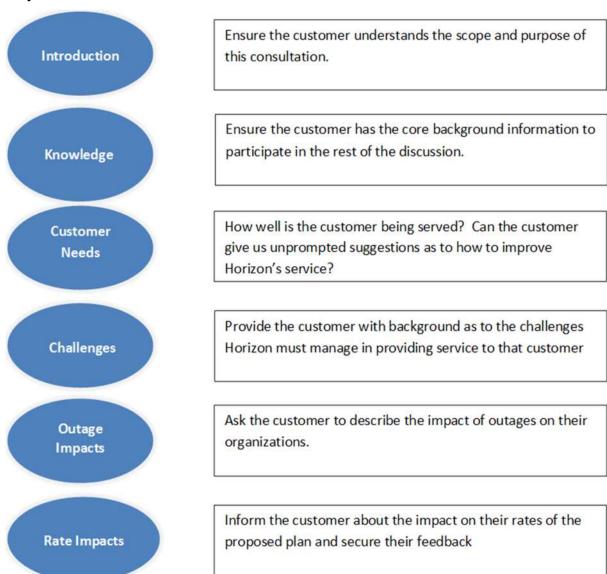
#### **Key Account Consultation Process**

INNOVATIVE assisted Horizon Utilities in developing the framework to consult with the key account rate class and to collect feedback on how the 5-Year Distribution System Plan will affect them.

The basic concept of the key account discussion was to cover the same issues as the broader consultation (which follows the consultation workbook). However, as expected, Key Accounts had a much stronger initial knowledge base and a much more specific understanding of their needs. That meant there was a higher demand for specific information about specific circuits, performance on those circuits and initiatives to enhance the reliability and security of those circuits.

With only a handful of Key Accounts, customer account managers at Horizon Utilities customized their consultation sessions for each customer, focusing on the issues that were most relevant to the client.

#### **Key Account Interview Structure**



#### Introduction

- In the past, Horizon Utilities used a Cost of Service approach; now it's using a Custom Incentive Regulation approach.
- The OEB requires Horizon Utilities to consult with its Key Accounts to discuss changes in price
- OEB Principle: Each rate class should cover the cost of servicing their needs. There will be no cross subsidizing between the rates classes.
- Where possible, Horizon Utilities estimated the particular Key Accounts' rate impact.

#### Knowledge

Horizon Utilities confirmed the key account participant understand what portion of the bill funds the distribution system, Horizon Utilities' role within the overall grid, and the rate setting process. If the key account participants were uncertain, Horizon Utilities staff reviewed the workbook material on *Electricity 101* and *Horizon Utilities System Today*.

#### **Customer Needs**

Before briefing key account participants on the plan, Horizon Utilities asked questions to gauge the unaided perceptions of the service they are receiving and any unmet needs:

- How satisfied are you with your overall experience with Horizon Utilities?
- Is there anything in particular we can do to improve our service to you?

#### Challenge in Providing Reliable Electricity

Horizon Utilities identified the challenges with the distribution system in the particular Key Accounts' service area.

Horizon Utilities structured discussions around the following three challenges where appropriate:

#### Capacity

• What are the growth pressures on the distribution system within the interviewee's service area (or even more targeted where possible)

#### Reliability

• SAIDI and SAIFI statistics (with and without adverse weather adjustments) within the interviewee's service area (or even more targeted where possible)

#### Security

- Examples of recent weather related service interruptions within the interviewee's service area.
- What are the vulnerabilities of local equipment failure within the interviewee's service area?

#### **Outage Experience and Needs**

After a discussion of reliability challenges, Horizon Utilities probed questions for reliability experience and outage impacts:

- Are you satisfied or dissatisfied with the current average number of electricity outages you have experienced?
- Are you satisfied or dissatisfied with the current average length of electricity outages you have experienced?
- How many outages have you experienced over the past year?

- How long have you lost power for when you lost power?
- What were the consequences to you of losing power?
- What sort of costs did you incur when you lost power?
- Is there a point in time at which the costs and consequences of an outage become more serious for you?

#### Distribution System Plan

Horizon Utilities then went on to discuss its 5 Year Distribution System Plan and what they were doing to address the challenges within the grid:

- Current: What we've done.
- Near-term: What we're planning to do over the next 5 years.
- Medium- and Long-term: What we plan to beyond the next 5 years.

Horizon Utilities also engaged in very specific discussions of the circuits serving these key account customers:

- Does this plan meet your needs?
- (IF NO) How can we improve the plan to better meet your needs?

#### Rate Impact

- Current: What Horizon Utilities has done;
- Near-term: What Horizon Utilities is planning to do over the next 5 years;
- *Medium- and Long-term*: What Horizon Utilities plans to do beyond the next 5 years.

Lastly, Key Accounts where asked what they thought about the rate change:

Considering what you know about Horizon Utilities' local distribution system, which of the following best represents your point of view:

- a. The rate change is reasonable and I support it;
- b. I don't like the rate change, but it is necessary; or,
- c. The rate change is unreasonable and I oppose it.

#### **Final Thoughts**

- How much is improving reliability worth to your business?
- What's the right balance when it comes to rate changes and providing better reliability to your business?
- What question do you have for us at Horizon Utilities?

#### **Participant Feedback**

The following section highlights the general feedback from the key account rate class group.

#### Overall Take-Away

Overall, considering what they know about the local distribution system, 5 out of the 9 Key Accounts interviewed believe that the rate change is reasonable and they support it. One of the Key Accounts interviewed stated that he does not like the rate change, but thinks it is necessary. Lastly, 3 other Key Accounts believe that the proposed rate change is unreasonable and therefore oppose it.

More specifically, most of the Key Accounts agreed with the rate change. One of them stated that he agreed with the new Distribution System Plan because it meant a "total decrease of 10% on the company's electricity bill". Furthermore, all of the Key Accounts understood the essential elements of the Distribution System Plan and that it was being carried out to compensate for and fund aging old infrastructure in the Hamilton and St. Catharines region.

Generally, the Key Accounts liked and agreed with the new cost of service plan laid out within Horizon Utilities proposed Distribution System Plan, as it meant a fairer price for the users involved. They stated that the current plan is a disadvantage to them as they are unfairly burdened to pay for distribution costs that they currently do not fully use and thus feel like they are charged extra to compensate for the smaller rate classes (e.g. residential and small business owners).

#### **Customer Experience and Expectation**

All of the 9 Key Accounts interviewed had an opportunity to express their concerns about how well Horizon Utilities is meeting their needs. Further, all of the Key Accounts interviewed stated that Horizon Utilities did a "good job" explaining the challenges being faced in maintaining the current distribution system.

#### System Renewal and Rate Impact

Out of the 9 Key Accounts interviewed, 2 of the Key Accounts thought that the proposed system renewal was "too fast". Further, 3 of the users stated that the proposed system renewal was "about right" and the remaining 3 users believed that the system renewal was "too slow". Lastly, one of the Key Accounts stated that he could not properly nor effectively answer this question because there was not enough information to make an informed decision on the proposed system renewal.

Two of the Key Accounts thought that the rate change was too aggressive in nature. One of the users stated that the increase is happening too fast, "10% increase each year is too fast for us as we will have a hard time adjusting to the increase". Further, these representatives stated that the plan should be spread out financially throughout the years, and should not be a "sudden jump" so that they are able fiscally manage the bill according to their budget. It is important to note that these two particular users were classified under General Service Users > 50Kw rate class, but were consulted as Key Accounts because they a represent a number of facilities that cumulatively, would place them in the key account rate class.

Some of the Key Accounts thought that the process of system renewal was too slow. They thought that the investment should happen faster in order to replace aging infrastructure. However, they ultimately agreed with the Ontario Energy Board and Horizon Utilities Distribution System Plan in rolling out a steady price change that customers can both afford and keep in pace with.

#### **Coverage of Distribution System Topics**

All of the 9 Key Accounts believed that Horizon's Distribution System Plan covered the key areas they expected (e.g. distribution lines, rate change, system renewal, system access, system service, and general plant issues).

One of the Key Accounts representing the stated that there was not enough information in the workbook to know whether Horizon Utilities proposed rate of system renewal was too fast, too slow, or about right. He wanted to know more about the system renewal process and where each of the funds would be invested in order to effectively and accurately answer the question.

Another one of the Key Accounts stated that there was no discussion by Horizon Utilities staff on consumption per unit pricing. This particular Key Account would've liked to see more updates and information on consumption per unit pricing and how Key Accounts would be affected by it.

#### How Could the Consultation Process be Improved?

Generally, all of the Key Accounts thought that the one-on-one interview carried out by Horizon Utilities staff were "professional", "educational", and "candid". They also thought that they were able to share and express their own perspectives and views effectively and openly with the Horizon staff without "being subjugated to any types of biasness or subjectivity".

Some of the Key Accounts stated that they were pleased that they could respectively "agree to disagree" with Horizon staff and their Distribution System Plan as there were no hostility or resistance from either side.

Lastly, all of the users interviewed stated that the interview process was the most effective way to discuss issues with them; as it allowed them to talk in an "open and free manner" with Horizon Utilities, which made the "process accountable and transparent".

#### Validation Interview Questionnaire Results

The following tables are the tabulations of key account feedback to validation questions Innovative Research Group asked following up on Horizon Utilities interviews with their key account rate class.

Reponses to open-ended questions are included in the body text of the previous sections.

Numbers in purple denote the total sum (the "Count" column). "KA#" denotes the response from a *Key Account* customer.

*Missing values* are recorded beneath each table to indicate the number of participants who left a particular question unanswered.

1. Can you please confirm that you recently met with representatives of Horizon Utilities about their Distribution System Plan?

| Response | KA1 | KA2 | КА3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Yes      | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 9     |
| No       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0     |

Missing values = 0

#### 2. Did you have an opportunity to express any concerns about how well Horizon Utilities is meeting your needs?

| Response | KA1 | KA2 | KA3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Yes      | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 9     |
| No       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0     |

Missing values = 0

#### 3. Did Horizon Utilities do a good job explaining the challenges they are facing in maintaining the system?

| Response | KA1 | KA2 | KA3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Yes      | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 9     |
| No       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0     |

Missing values = 0

#### 4. Did the Distribution System plan cover the key areas you expected?

| Response | KA1 | KA2 | KA3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Yes      | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 9     |
| No       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0     |

Missing values = 0

#### 5. Do you feel Horizon Utilities proposed rate of system renewal is too fast, too slow or about right?

| Response    | KA1 | KA2 | КА3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Too fast    | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 1   | 2     |
| About right | 1   | 1   | 1   | 0   | 0   | 0   | 0   | 0   | 0   | 3     |
| Too slow    | 0   | 0   | 0   | 1   | 0   | 1   | 1   | 0   | 0   | 3     |

Missing values = 1

#### 6. Considering what you know about the local distribution system, which of the following best represents your point of view:

| Response   | KA1 | KA2 | KA3 | KA4 | KA5 | KA6 | KA7 | KA8 | KA9 | Count |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| The proposed rate change is reasonable and I support it            | 1   | 1   | 1   | 1   | 0   | 0   | 0   | 1   | 0   | 5     |
| I don't like it, but I think the proposed rate change is necessary | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 1     |
| The proposed rate change is unreasonable and I oppose it           | 0   | 0   | 0   | 0   | 1   | 0   | 1   | 0   | 1   | 3     |

Missing values = 0

**NOTE**: the question wording has been changed for this phase of the consultation from "proposed rate increase" to "proposed rate change" as most Key Accounts will be experiencing a decrease in rates under Horizon Utilities' proposed plan. Also, two "Key Accounts" are actually in the GS > 50 kW rate class, but are treated as Key Accounts because they represent a number of facilities that cumulatively, would place them into this larger rate class.

## Appendix:

Horizon Utilities' DSP Workbook





# Distribution System Plan Review WORKBOOK



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| Horizon Utilities' Distribution System Today    | 9  |
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| Controlling Costs                               | 17 |
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This review is focused on the near-term plan for Horizon Utilities Corporation's distribution system over the next five years.

If you are interested in broader medium- and long-term electricity issues such as Ontario's energy supply mix, conservation planning and general energy policy in the province, there are other opportunities for you to be heard.

Ontario's Long-Term Energy Plan: The Ontario Government's Plan details how electricity will be generated and the longer-term conservation strategy for the province. It can be found at this website: www.energy.gov.on.ca/en/ltep/

**Regional Planning**: The Ontario Power Authority (OPA) looks ahead to the future electricity needs of your region and how those needs can be addressed through conservation, local generation and electricity from outside the region. You can follow the OPA's regional planning process at this website:

www.powerauthority.on.ca/power-planning/regional-planning

#### What is this about?

## Thank you for your participation in Horizon Utilities Corporation's distribution system plan review

The purpose of this workbook is to get your feedback on Horizon Utilities' plan to distribute electricity in the Hamilton and St. Catharines service areas over the next five years. We want to make sure that we get this right and we need your feedback. This is an opportunity for you to tell us what you think about our plans. This is about helping us to serve you better. This is also an opportunity for us to communicate to you about the challenges our electric system will be facing and, more importantly, how we intend to meet those challenges over time.

We've engaged an independent, third-party research firm (Innovative Research Group Inc.) to collect customer feedback to ensure the integrity of our process.

## While this plan requires an increase in rates, costs have been maintained to be as affordable as possible

What might this mean to your bill?

Residential Customers: As you can see in the sample bill on the following page, distribution charges are part of the Delivery charge and are about \$27 of an average residential electricity bill. We estimate that an additional \$1.12 per month each year (or about 4.2% per year) will be required over the next 5 years to address the needs of the local electricity system.

General Service Customers: For small businesses and organizations in the General Service (GS) under 50 kW rate class, distribution charges are about \$50 of an average electricity bill and the increase will be about \$2.12 per month each year (or about 4.2% per year) over the next 5 years for this group.

For larger businesses and organizations in the General Service **over 50 kW** rate class, distribution charges are about \$820 of an average electricity bill (based on monthly demand of 250 kW) and the increase will be about **\$77.64 per month** each year (or about 9.5% per year) over the next 5 years for this group.

### You don't have to be an electricity expert to participate in this review

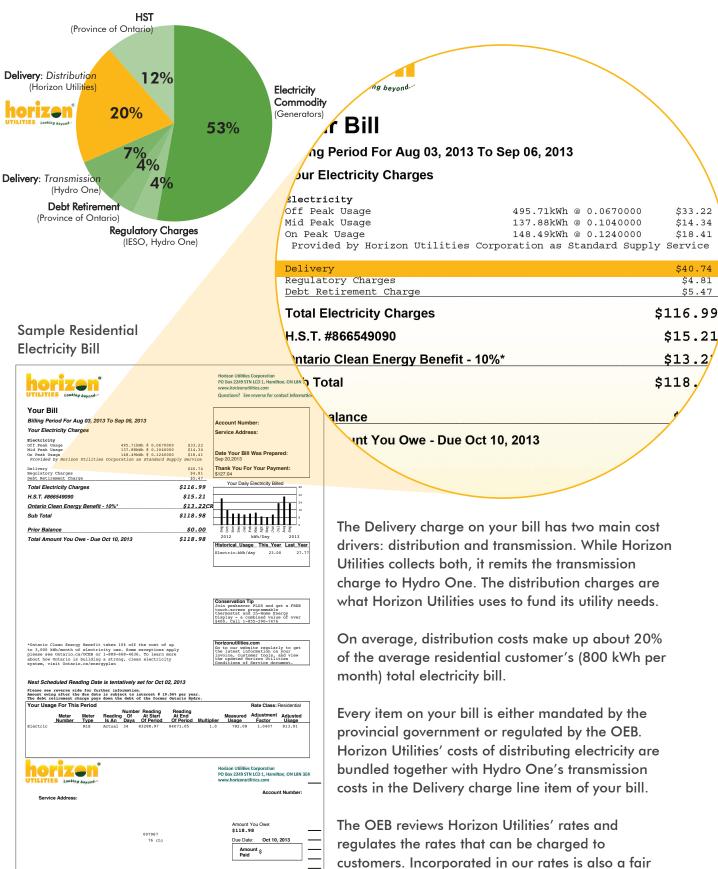
The following sections of the workbook explain the key elements of our system, the challenges facing the system, our recent work to maintain the system, and our plan for the next five years.

Our engineers are reviewing the technical requirements and feasibility of various options to ensure service at the lowest possible costs.

Understanding the needs and priorities of our customers and the communities we serve allows us to consider your views as we finalize our plan for submission to the Ontario Energy Board (OEB), the regulatory agency that sets electricity rates for all utilities in Ontario.

For a brief overview of Horizon Utilities' background and history, please see Appendix A: About Horizon Utilities Corporation (page 23).

## 20% of your total electricity bill goes to Horizon Utilities



return on our capital investments.

#### **Electricity Grid 101**

## Who Does What in Ontario's Power System?

Ontario's electricity system is owned and operated by public, private and municipal corporations across the province. Electricity systems – whether in Ontario or other jurisdictions – have three key components: **generation**, **transmission** and **distribution**.



#### **GENERATION**

Generating facilities convert various forms of energy into electric power.

#### **EXAMPLE**

Ontario Power Generation TransCanada Energy Ltd Bruce Power Samsung Renewable



#### **TRANSMISSION**

Transmission lines connect the power produced at generating facilities to substations.

#### **EXAMPLE**

Hydro One Great Lakes Power Canadian Niagara Power



#### **DISTRIBUTION**

Distribution lines carry electricity to homes and businesses.

#### **EXAMPLE**



Burlington Hydro Niagara-On-The-Lake Hydro



#### **CONSUMERS**

Electricity is delivered to homes and businesses.

#### **EXAMPLE**

Residential Commercial Industrial

#### How is Ontario's Power System Regulated?



INDEPENDENT ELECTRICITY

SYSTEM OPERATOR



**ONTARIO ENERGY BOARD** 



**ONTARIO POWER AUTHORITY** 







RULES + POLICY + LICENCES + RATE







**CONSUMER PROTECTION** 

#### **Ontario Ministry of Energy:**

The Ontario Ministry of Energy creates energy policy. It sets the rules and establishes key planning and regulatory agencies through legislation.

#### **Ontario Power Authority:**

The Ontario Power Authority (OPA) is responsible for medium and long-term electricity planning to ensure an adequate supply of electricity is available for Ontario residents and businesses. The OPA receives directives from the Ministry of Energy (i.e. energy supply mix, Green Energy Act), but otherwise works at arm's-length from the government.

#### **Independent Electricity System Operator:**

The Independent Electricity System Operator (IESO) is responsible for electricity supply over the short-term. It operates the grid in real-time to ensure that Ontario has the electricity it needs, where and when it needs it.

#### Ontario Energy Board:

The mission of the Ontario Energy Board (OEB) is to promote a viable, sustainable and efficient energy sector that serves the public interest. It is an independent body established by legislation that sets the rules and regulations for the provincial electricity sector. Of particular importance to this discussion is the fact that the OEB reviews the distribution plans of all electricity distributors and sets their rates.

#### Horizon Utilities' Distribution System Today

Horizon Utilities has some of the oldest distribution assets in the province. Some of the equipment serving Hamilton and St. Catharines has been in service for nearly 100 years.

Electricity investment comes in cycles of growth. A significant portion of our existing system was installed during expansions in the 1950s to the 1970s, when Hamilton and St. Catharines grew. Since then, the way we use electricity has changed significantly. Through careful management, we have been able to make full use of and, where possible, extend the life of this equipment. But now, we have reached the point where 50% of our equipment is operating beyond, or close to, end-of-life expectancy. While much of that equipment is still in good shape and will continue to operate for several more years, we need to prepare to replace that equipment sooner rather than later.

#### System Reliability

For most customers, the key test of the system is "do the lights stay on". We track both the number of power service interruptions per customer and how long those outages last.

Since 2006, the average number of times customers have experienced a power service interruption has increased by 35% (to about two times a year), while the average length of the power service interruption has risen by 54% (to about 1.5 hours).

This trend is largely due to a higher occurrence of adverse weather and an increase in equipment failure. Replacing our aging equipment is a key part of the plan that we will be laying out for your review and input.

#### Paying for the Distribution System

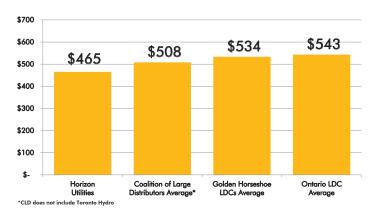
As anyone who runs their own business would expect, we manage our spending in two budgets – an operating budget and a capital budget.

Our **operating budget** covers regularly recurring expenses such as the costs of running our vehicles, the payroll for our employees, and the maintenance of our distribution equipment and buildings.

Our **capital budget** covers items that, when purchased, do not need to be repurchased for some time and that have lasting benefits over many years. This can include much of the equipment that is part of the distribution system, such as poles, wires and transformers, major computer systems, and vehicles.

Over the last five years, our average annual operating costs per customer has been \$179, compared to the industry average of \$270 per year. This means that across the province, Horizon Utilities' costs are nearly 34% lower than other local distribution companies. By managing costs and organizational efficiencies, we have kept our operating costs among the lowest in the sector.

#### **Distribution Revenue Per Customer (2012)**



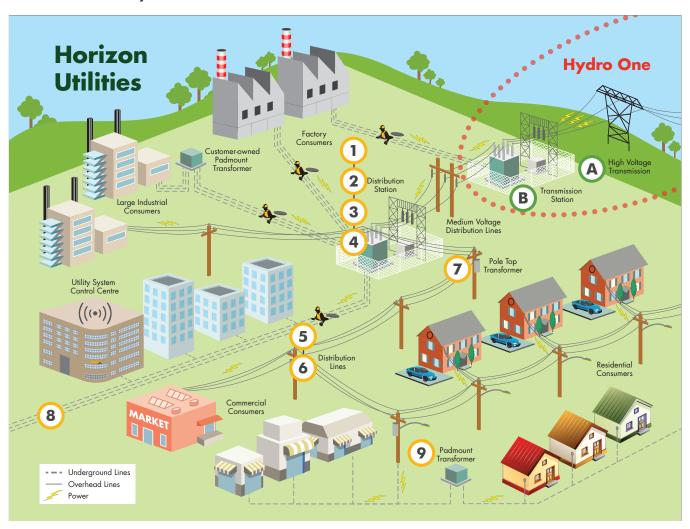
# Your distribution system has three main equipment categories: distribution stations, overhead system, and underground system.

Hydro One's high voltage transmission lines connect the power produced at generating stations across the province (nuclear power plants, gas power plants, hydroelectric dams, wind farms, etc.) to transmission stations in Hamilton and St. Catharines. From Hydro One's transmission stations electricity flows to our distribution stations; this in turn, energizes our entire distribution system.

#### Hydro One's Transmission System

- A High Voltage Transmission connects our distribution system to electricity generating stations across the province.
- B Transmission Station reduces high voltage electricity from transmission lines to medium voltage which is fed into our distribution stations.

#### **Your Distribution System**



#### Horizon Utilities' Distribution System

#### **Distribution Stations**

Distribution stations are a critical element of the electricity grid—they are the local hubs from where electricity is distributed to an area. Distribution stations contain:

- 1 Transformers devices that reduce the voltage of electricity to a lower level for use in the local distribution system.
- **Breakers** safety devices that interrupt a circuit if an unsafe amount of electricity passes through it (similar to a breaker panel in your home, except much larger).
- Switches devices that control the flow of electricity. They direct which supply of electricity is used and which circuits are energized.
- Feeder Circuits are the wires that exit the distribution station and deliver electricity to customers.

#### Overhead System

The overhead system includes the wires that are commonly seen across Horizon Utilities' service area. The voltage of the overhead system can be from 4 kV (1000 volts) to 28 kV.

- Wires there are 1,500 km of wire that carry electricity across our overhead distribution system.
- 6 Poles wires are suspended from these usually wooden (sometimes concrete) poles.

Pole Top Transformers – these transformers are mounted near the top of utility poles and are needed to further step-down the voltage from the lines to the final connection to customers.

#### **Underground System**

The underground system includes 1,900 km of cable, some of which are direct buried (exactly as it sounds), and much of it is installed in ducts. At certain intervals underground service chambers (with manholes) are required to permit cables to be spliced together and to allow underground equipment such as switches to be housed.

A big advantage of underground systems is that they are less affected by weather. The disadvantage is that they are more expensive to install and maintain, and when there is a power outage it often takes longer to locate and repair a problem compared to overhead wires. Currently, about half of the outages caused by equipment occur in our underground system.

- Underground Cable convey the electricity in the underground system. Cables that connect the distribution stations and major industrial users to the distribution station are significantly larger than cables used to connect residential neighbourhoods, as one would suspect.
- Padmount Transformers similar to transformers in the overhead system, these reduce the voltage to a lower level before final connection to customers. In the underground system there are concrete padmounted transformers, which are above ground transformers that are supplied by underground cable, and vault transformers, which are housed in underground chambers.



| - 4 6 11 1        |             |               | .1            |            |                 |            |      |
|-------------------|-------------|---------------|---------------|------------|-----------------|------------|------|
| For the following | auestions r | nlease select | the answer ti | hat best i | renresents volu | r noint ot | VIEW |
|                   |             |               |               |            |                 |            |      |

|            | The following questi   |   |   |  |
|------------|--|---|---|--|
| 1          | Did you experience a power service interruption in the last year?  • Yes • No • Don't Know   |   |   |  |
| 2          | If so, how long did your most recent power service interruption last?  |   |   |  |
|            |  |   |   |  |
|            |  |   |   |  |
| 3          | If you did experience a power service interruption, how satisfied were you with the way that Horizon Utilities responded to that power service interruption? |   |   |  |
|            | <ul> <li>Very Satisfie</li> </ul>  | d (                                       | Somewhat Satisfied  |  |
|            | <ul><li>Not Very Sat</li></ul>   | tisfied (                                 | Not Satisfied At All  | <ul><li>Don't Know</li></ul>   |
| 4          | Is Horizon Utilities response to power service interruptions getting better or worse?  |   |   |  |
|            | Much Better  |   | Somewhat Better   |  |
|            | <ul><li>Somewhat V</li></ul>   | Vorse (                                   | Much Worse  | <ul><li>Don't Know</li></ul>   |
| ho<br>Plec | ase answer the follow  | no interruptions.                         | ns, from your point of view                                 |  |
| 5          |  |   | ns are reasonable in a year                                 | r¢   |
|            | <ul><li>None</li></ul>   | <ul><li>One</li></ul>                     | • Two   |  |
|            | <ul><li>Three</li></ul>  | <ul><li>Four</li></ul>                    | <ul><li>More than four</li></ul>                            | <ul><li>Don't Know</li></ul>   |
| 6          | <b>5</b> What is a reasonab  | le duration for a                         | service interruption?                                       |  |
|            | <ul><li>0 minutes</li></ul>  | <ul><li>30 minutes</li></ul>              | 1 hour  |  |
|            | <ul><li>2 hours</li></ul>  | <ul><li>3 hours</li></ul>                 | <ul><li>4 hours or more</li></ul>                           | <ul><li>Don't Know</li></ul>   |
|            | 2 110013   | O O HOOIS                                 |   | Don't know   |
| 7          | 7 From your perspect   | rive, if Horizon Ut<br>are focus on reduc | ilities is able to improve the<br>ing the number of power s | e reliability of its distribution system, ervice interruptions or reducing the |

# Challenges Facing Our Distribution System

## As we look ahead to our plan for the next five years, what are the major issues we need to address?

The expansion of the local distribution system in Hamilton and St. Catharines was among the first in Canada. Over the years, our employees have worked hard to keep our equipment working well beyond its originally expected life, to get maximum value for money. However, now there are many parts of the system for which we will not be able to continue to extend the operating life. While we do have some specific areas that

will need additional capacity, our key challenges come from the need to replace aging equipment while supporting growth in certain areas of our communities.

To assist us in prioritizing what needs to be replaced and by when, we utilize an asset management model to drive replacement decisions.

Using the information provided by the asset management model, we plan for four types of capital replacement costs:

## **System Access**

**Definition:** Projects that respond to customer requests for new connections or new infrastructure development. These are usually a high priority, "must do" type of requests.

**Programs** (e.g.): Customer Connections, Street Lighting

## System Renewal

**Definition:** Projects focused on replacing aging equipment in poor condition.

Programs (e.g.): Distribution Station Refurbishment, Voltage Conversion, Underground Cable Replacement, Overhead Wire Replacement

## **System Service**

**Definition:** Primarily consisting of projects that improve system reliability.

**Programs** (e.g.): Automated Switches, better distribution system monitoring equipment

## **General Plant**

**Definition:** Investments in supporting assets, such as tools, vehicles, buildings and information technology (IT) equipment that are needed so that we may perform our task to operate and maintain the distribution system.

**Programs** (e.g.): IT, Facilities, Fleet

## System Service

## General Plant

System Service projects are initiated to deal with reliability and security issues rather than equipment failure. There are several projects being proposed to provide support to areas that are growing or to allow better use of existing equipment. Spend in this area is stable and not expected to be more than what has been required in the past on a go forward basis.

Just as with our distribution system, the buildings and equipment we need to support our business – facilities, IT and vehicles – are in need of refurbishment and replacement. We have made good progress on protecting and refurbishing our buildings to halt further degradation and make them more productive work environments over the last few years. The pace of investment will slow going forward as this is near completion.

 Automated switches to minimize the duration of a power service interruption.

- Building renewal plan to bring existing facilities into compliance with current building codes and increase space utilization
- Ongoing fleet management to maintain and replace service vehicles
- IT renewal program

System Service projects are initiated to expand capacity for future growth or to deal with reliability and security issues that are driven by grid design rather than equipment failure. Our distribution system is well-developed and there are relatively few of these projects within the plan.

One project involves replacing older switches with automated switches which will reduce the restoration time for a power service interruption. Today, one has to wait for a service crew to arrive on the scene and to manually operate switches and move to the next location and repeat this task to restore the network. An automated switch will be able to operate remotely from a central control room. Another example will be to add a third feeder line in Waterdown to facilitate new development in the area. These projects will help to limit outages, reduce the length of outages, and reduce bottlenecks that will allow us to make better use of existing lines.

Operating the business effectively requires that Horizon Utilities' employees have offices and service centres to work in, vehicles to drive and IT systems to manage business functions.

With a significant amount of our renovation program completed, capital expenditure on buildings will drop from just under \$4 million in 2015 to just under \$2 million in 2019.

Vehicle financing is projected at just under \$800,000 for all five years. This is down \$300,000 from previous years to mitigate our need for and increased expenditure in building renovations.

It is important that we have the technology and systems available to serve our customers. IT expenditure will be higher in 2015 at \$4 million as we complete a major and necessary overhaul of our core business management software.

## **System Access**

Our communities developed in large part in the 50s, 60s, and 70s. Meeting the demand of new growth is currently limited to a few areas in the community. We expect the costs in this area to remain relatively stable.

Investments for new customer connections are spread over 40 years which keeps overall costs lower for everyone.

- Connecting businesses to the distribution system based on growth of the Hamilton Port and downtown commercial property redevelopment
- The village of Waterdown in Flamborough is experiencing one of the highest rates of residential growth in our service area, requiring new connections to the distribution system.

System Access projects include the type of action needed to enable new connections to the grid or to make changes to equipment to keep pace with customer requirements. This type of capital expenditure is mandated by legislation and scheduled by customer request.

In addition to the regular demand from customers using electricity, we are now enabling projects under the FIT and microFIT programs that supply renewable electricity to the grid.

Other projects will include moving the poles for the widening of Rymal Road in Hamilton within the next few months.

Based on past experience, we are projecting expenditures to be fairly stable over the next five years at approximately \$6 million.

## System Renewal

Although our equipment is in reasonably good shape for its age, it is getting old and much of it will need to be replaced soon.

The time lost to power service interruptions caused by aging equipment has been growing steadily over the past decade. We started to replace critical equipment in our distribution stations as well as the grid in downtown St. Catharines. We need now to manage the balancing act of replacing equipment proactively before it fails. Proactive replacement is less costly than replacing equipment on a reactive basis.

- Low voltage renewal plan
- Distribution station decomissioning
- Coordination of renewal of Gage Transmission Station with Hydro One
- Proactive underground cable replacement in St. Catharines, Hamilton Mountain and Stoney Creek

System renewal is by far the biggest financial and operational challenge facing the grid. Projects to replace aging elements of the grid that are in poor condition or at high risk of failure will be a key driver of rate increases in this application and for the foreseeable future.

An independent engineering firm that analyzed the health of the Horizon Utilities' system assets has identified a 20-year investment requirement of approximately \$700 million. The analysis indicates that Horizon Utilities' reliability of the distribution system is worsening and investments are required to maintain the reliable service we all expect.

We propose increasing annual renewal investment from the current rate to an annual value of \$35 million by 2019 and approximately \$37 million by 2025.

Based on our engineering studies this is the minimum investment level required to maintain the current health of our major asset categories through 2019.



| For t | he t | follo | owin | a a | iuestions. | please | select | th | e answer | that | best | rer | presents | vour | point | of v | view. |
|-------|------|-------|------|-----|------------|--------|--------|----|----------|------|------|-----|----------|------|-------|------|-------|
|       |      |       |      |     |            |        |        |    |          |      |      |     |          |      |       |      |       |

| _ | How satisfied are | ***       | •       •               | • • • •             |                     | ''I '' ' '          |
|---|-------------------|-----------|-------------------------|---------------------|---------------------|---------------------|
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|   |                   |           |                         |                     |                     |                     |
|   |                   |           |                         |                     |                     |                     |

- Very Satisfied
- Somewhat Satisfied
- Don't Know

Somewhat Dissatisfied

the following best represents your view?

- Very Dissatisfied
- 2 Is there anything in particular Horizon Utilities can do to improve their service to you?

In order to secure the full value for its investment, Horizon Utilities allows some equipment to "run-to-failure". The equipment that is allowed to run-to-failure (such as pole top transformers) only creates power service interruptions for a very limited number of customers and can quickly be restored. While many utilities follow this practice, others do not. Which of

- "Running-to-failure" is a good way to get full value from equipment so long as the resulting power service interruption is contained and quickly restored.
- Horizon Utilities should ensure reliable power and not wait until equipment fails, even
  if that means it needs to spend more money replacing equipment that is still working.
- Don't Know

# **Controlling Costs**

In our last OEB rate application three years ago, we set out a plan to control costs and to begin addressing aging infrastructure in key parts of our distribution system.

Before we ask our rate payers for more money, we have an obligation to ensure we are getting the best value we can from the revenue we already receive from customers.

We have been able to deliver among the lowest operating costs and the lowest residential and commercial rates in Ontario.

We have kept our costs down with a productivity strategy that focuses on delivering more or better service for the same costs or less. We have been lowering training costs, and increasing tool time (the amount of onsite work vs. travel time and administration) across the organization. We are a company of 400 employees and we expect productivity to improve by approximately \$3 million between 2012 and 2014.

# Conservation and Demand Management (CDM)

Conservation programs are a key part of Ontario's Long-Term Energy Plan to meet the needs of electricity customers while contributing to improvements in air quality and reducing greenhouse gases. Investing in conservation is a cost effective means by which to reduce the amount of electricity used rather than build new generation resources.

We have been actively working with customers to implement conservation initiatives for many years. In 2011, the OEB mandated aggressive Conservation and Demand Management targets for all local distribution companies in Ontario to be met by the end of 2014.

With the help of our customers, our conservation programs have delivered energy savings of over 110 million kilowatt-hours (kWh) and 31 thousand kW of peak demand between 2008 and 2012. These savings represent the equivalent of taking close to 12,000 homes off the grid for one year. Additional savings of 64 million kWh and 15,000 kW of peak demand are expected to be realized by the end of 2014; this represents a further reduction in electricity that is equivalent to taking 6,600 homes off the grid for one year. Local businesses in Hamilton and St. Catharines have received over \$17 million in incentives, funded by the Ontario Power Authority, for their energy conservation efforts.

## Getting the Most From Our Assets

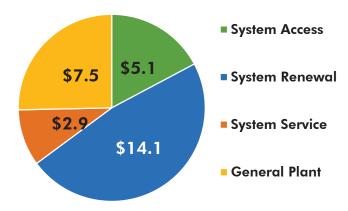
Another important way we keep costs down is by carefully managing and maintaining our equipment to extend its life. The people who built our system built it well, and we avoided replacing useful equipment for as long as was reasonably possible. We work hard to extend the service life of all of our equipment, but we have now reached a point where much of our system will need to be replaced within the foreseeable future.

As mentioned earlier, we use an asset management model to identify key replacement priorities. There are a large number of challenges that must be dealt with, but we don't have to fix it all at once. The key to having an asset management plan is that it guides our decisions about when the timing is right to replace assets.

# We have already started to renew

Our 2008 asset management plan identified several immediate priorities for replacement. Since then, our investment in annual renewal has grown from just under \$10 million to \$17 million.

#### 2012 Capital Expenditures (\$ millions)



Distribution stations play a critical role connecting the distribution grid so they have been the top priority for new investment. Some of the work we have already completed includes:

**Distribution station transformers:** Six distribution transformers in very poor condition were replaced. In four of the installations, we used refurbished transformers, which are half of the cost of a new transformer.

**Distribution station switchgear:** A full switchgear replacement was done at one station due to a significant number of equipment health issues. That distribution station will be in service for at least another 35 years. As a result, a full replacement ensures we are utilizing this asset to its full potential.

Distribution station assets (breakers and relays): These assets were prioritized based on the condition of the assets and how long the station would continue to be in service for the surrounding community. New breakers have been standardized and take full advantage of technological innovation. All of our distribution station equipment that is removed from service is refurbished and used for spare parts, if it qualifies. The station breaker program was initiated and completed in 2012 and 2013. No further investments in distribution station circuit breakers are forecast from 2015 through 2019.

In addition to the distribution station work, we also have given priority to a program that is replacing aging equipment with new technology:

Voltage conversion program: A key element of our overhead plan is the conversion of our 4 kV and 8 kV distribution systems. These systems serve approximately 82,000 customers representing 34% of the total customer base scattered across all of our operating areas. These lines worked well when they were first installed in the 1950s, but new lines use higher voltage for better efficiency. We have organized this work to give priority to lines that are supported by distribution station equipment that is in poor condition so we can optimize our renewal plans for both distribution station and overhead lines.

## What Our Plan Means For You

## We have worked hard to deliver among the lowest operating costs and the lowest residential and commercial rates in Ontario.

While we do our best to keep our rates low, over the past three years our rate increases have actually been lower than they should have been to maintain the system adequately.

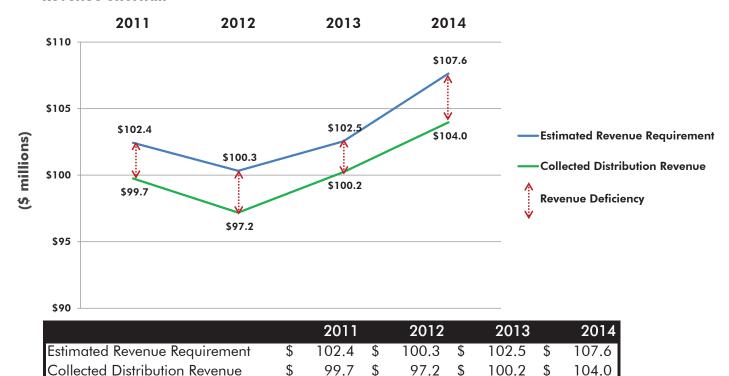
In our last rate application, only one approach was available for all utilities to follow. Rates in 2011 were set using a cost of service method, which looked at the actual costs of providing electricity distribution in our service area. Then once those cost of service rates were set, a mechanistic formula was applied each year to account for inflation less an adjustment for

efficiency. This method resulted in a revenue shortfall for us since investments made over time were not recognized and thus did not allow for any adjustment to our growing rate base.

The result can be seen in the chart below. We have built up a revenue shortfall of \$12 million since 2011. This has reduced our ability to reinvest in our system. Given that so many of our assets have reached their end-of-life or are approaching, we need to correct this problem and make the required replacements.

The OEB has recognized this problem and has now given utilities in Ontario a number of options to calculate their rates. At Horizon Utilities, we will be using the Custom Incentive Rate cost of service approach where our rates will be based on actual costs each year of our five year plan.

## **Revenue Shortfall**



(2.7)

(3.1)

(2.3)

(3.7)

Revenue Deficiency

## Addressing the Revenue Shortfall

Despite our relatively old equipment, we run our operation on less money per customer than the average electricity distributor in Ontario. However, under the previous rate approval process, our actual costs were not fully covered. This has left us with a gap, which we need to address in this rate application.

Our current rate application will avoid the revenue shortfall that occured over the past several years.

Looking across the full five year period, while the bulk of our spending is for the renewal of our aging equipment, we will also be applying for an increase to our operating budget. Most of our operating budget increase comes from rising labour costs and inflation (rising fuel, materials such as wire, and equipment costs.) Those increases will be offset by ongoing efforts to improve productivity. After expected productivity savings, the average increase in operating costs is 2.1% a year for a total of approximately \$7 million over the five years.

## Rate Changes

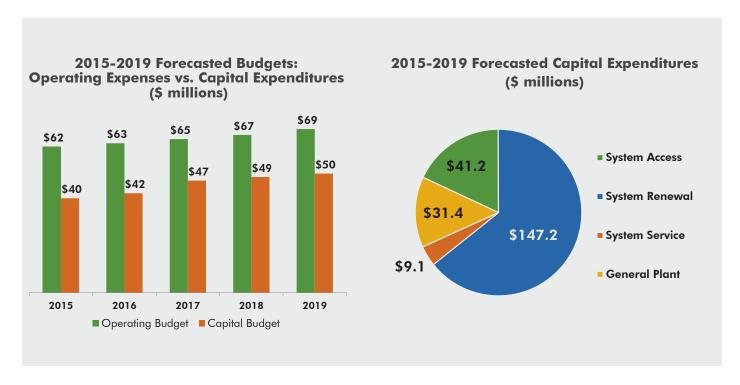
Different classes of customers will have their rates affected in different ways.

The OEB has established that each rate class should pay for the cost of serving that class; this is a core OEB rate-making principle. Applying this principle will result in different rate increases for different users.

Following the last rate application, we discovered that large use rate class customers were being charged an inequitable share of costs. As part of this rate application, we are proposing to revise our rate structure in the following manner:

- By creating a new rate class for the largest users who were paying much more than their fair share; and,
- By assessing the rates of all rate classes to appropriately reflect the cost of service.

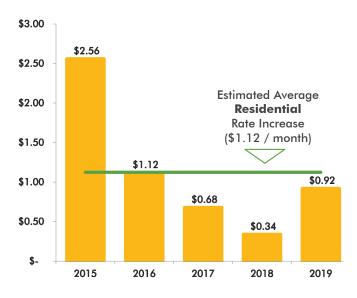
While no one wants to see a price increase, the OEB's direction to ensure each rate class pays its own share of the costs is central to its core principle of ratepayer equity. All utilities in Ontario are required to comply with this mandate.



# What Does this Mean for Residential Customers?

Those customers with an average monthly consumption of 800 kWh may see an average rate increase of 4.2% on the distribution portion of their bill for the next five years. That works out to an average annual increase of approximately \$1.12 a month, each year. As such, by 2019, the average residential household will be paying an estimated \$5.60 more per month on their distribution portion of their electricity bill.

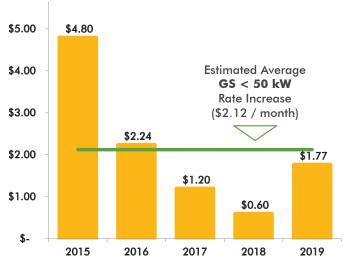
#### **Estimated Average Residential Rate Increase**



# What Does this Mean for Commercial Customers?

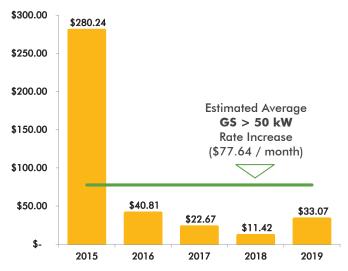
GS < 50 kW: Those customers with an average monthly consumption of 2000 kWh may see an average rate increase of 4.2% on the distribution portion of their bill for the next five years. That works out to an average annual increase of approximately \$2.12 a month, each year. By 2019, the average small business will be paying an estimated \$10.60 more per month on their distribution portion of their electricity bill.

#### Estimated Average GS < 50 kW Rate Increase



GS > 50 kW: Those customers with an average monthly demand of 250 kW may see an average rate increase of 9.5% on the distribution portion of their bill for the next five years. That works out to an average annual increase of approximately \$77.64 a month, each year. Therefore, by 2019, the average GS > 50 kW customer will be paying an estimated \$388.20 more per month on their distribution portion of their electricity bill.

#### Estimated Average GS > 50 kW Rate Increase



Based on the current plan, we expect that the increases for all customer classes in the earlier years may be higher followed by lower increases in the later years.



For the following questions, please select the answer that best represents your point of view.

| 1 | Did H | orizon Utilities' Distribution System Plan cover the topics you expected?   |
|---|-------|---|
|   | •     | Yes No Don't Know   |
|   |       | If No: What was it missing?   |
|   |       |   |
|   |       |   |
|   |       |   |
| 2 |       | on what you already knew and what you have read in this workbook, do you feel you a good general sense of how the Horizon Utilities' distribution system works?                     |
|   | •     | Yes ● No ● Don't Know   |
| 3 |       | on what you already knew and what you have read in this workbook, do you feel you<br>a good general understanding of the challenges regarding Horizon Utilities' distribution<br>n? |
|   | •     | Yes No Don't Know   |
| 4 |       | dering what you know and have learned about the local distribution system, do you fee oposed rate of system renewal is  |
|   | •     | Too Slow ● Too Fast ● About Right ● Don't Know  |
|   |       | Why do you say that?  |
|   |       |   |
|   |       |   |
|   |       |   |
| 5 |       | dering what you know about the local distribution system, which of the following best sents your point of view:   |
|   | •     | The rate increase is reasonable and I support it  |
|   | •     | I don't like it, but I think the rate increase is necessary   |
|   | •     | The rate increase is unreasonable and I oppose it   |
|   | •     | Don't Know  |
|   |       | Why do you say that?  |
|   |       |   |
|   |       |   |
|   |       |   |

# **About Horizon Utilities Corporation**

## **APPENDIX A**

# Horizon Utilities serves the cities of Hamilton and St. Catharines.

We are locally owned by the City of Hamilton and the City of St. Catharines, with a long and proud history of industry leadership. Today, we are one of the largest municipally owned electricity distribution companies in Ontario. The company provides electricity and related utility services to 239,000 residential, commercial and industrial customers in Hamilton and St. Catharines.

## Our History Helps Define Us

| 1883          | Hamilton installs Canada's first incandescent streetlights  |
|---------------|---|
| 1884          | Incorporation of St. Catharines Electric Light and Power  |
| 1898          | DeCew Falls station in St. Catharines is the oldest continually running hydroelectric plant in Canada and is connected to Hamilton by the world's first long-distance transmission line, at 56 kilometres |
| 1911          | Hamilton voters support creating Hamilton Hydro in a municipal referendum   |
| 1914          | St. Catharines Hydro is established   |
| 1960s – 1990s | Ongoing infrastructure and technological investments ensure robust and reliable electricity distribution networks in St. Catharines and Hamilton  |
| 2005          | Hamilton Hydro and St. Catharines Hydro merge to form Horizon Utilities – becoming the then third largest municipality-owned electricity distributor in Ontario   |
| 2008          | Horizon Utilities is the first electricity distribution company in Canada to make a full sustainability report<br>under the Global Reporting Initiative (GRI) framework                                   |
| 2011          | Horizon Utilities is awarded Canadian Electricity Association's Sustainability Company of the Year and named to Hamilton-Niagara's Top Employers list   |

Horizon Utilities serves a diverse group of customers. We have over 200,000 residential customers, more than 18,000 general service customers who take less than 50 thousand watts (kW) of energy, about 500 general service customers that require more than 50 kW, and 11 large users who use more than 5,000 kW of electricity, monthly.

Under OEB direction, we are required to do our best to ensure the rates from each class of customers covers the cost of serving those customers.



# Questions and Comments

If you have any questions or comments about Horizon Utilities' Distribution System Plan Review please email:

## DSPreview@horizonutilites.com

or send your questions or comments to:

## **Horizon Utilities Corporation**

Attn: DSP Review 55 John Street North Hamilton, ON L8R 3M8

## **Appendix E – Renewable Energy Generation**



# Horizon Utilities Distribution System Plan Appendix E – REG Investment Plan

#### <u>Introduction</u>

On March 28, 2013, the Ontario Energy Board ("OEB" or the "Board") issued Chapter 5 of the Board's Filing Requirements for Electricity Transmission and Distribution Applications, entitled *Consolidated Distribution System Plan Filing Requirements* (the "DS Plan Filing Requirements") which reflects the Board's policy direction on an integrated approach to distribution network planning. Horizon Utilities has prepared its DS Plan in accordance with these DS Plan Filing Requirements.

The Board issued a letter dated March 28, 2013 accompanying the DS Plan Filing Requirements. In that letter, the Board stated that "under the renewed regulatory framework for electricity, a distributor's investments to accommodate and connect renewable energy generation and to develop and implement a smart grid are integral to its overall capital expenditure plan."

Section 5.1.4.2 of the DS Plan Filing Requirements requires that distributors submit information to the Ontario Power Authority (the "OPA") in relation to the renewable energy generation ("REG") investments identified in its DS Plan. The OPA is expected to provide a letter of comment with regard to these plans. Horizon Utilities' REG Plan forms part of its overall Distribution System Plan. Horizon Utilities has separated its REG Plan for the purpose of the obtaining OPA's review and letter of comment. The Board's expectations for the OPA's comment letter are summarized in Attachment A. A copy of the OPA's comment letter will, once complete, be attached as Attachment B.

## 1. Summary of Renewable Energy Generation Investments (5.4.1(g))

Horizon Utilities is one of the largest municipally-owned electricity distribution companies in Ontario, providing electricity and related utility services to more than 240,000 residential and commercial customers in Hamilton and St. Catharines. The company is owned by Horizon Holdings Inc., a company jointly owned by Hamilton Utilities Corporation and St. Catharines Hydro Inc. The latter two companies are respectively owned by the City of Hamilton and the City of St. Catharines.

Horizon Utilities is supplied through the Hydro One Networks Inc. transmission system at voltages of 13.8 kV and 27.6 kV. Electricity is then distributed through Horizon Utilities' service area of 426 square kilometres over 1,904 kilometres of underground cable and 1,524 kilometres of overhead cable and 52,000 poles. Horizon Utilities not only delivers electricity at its supply voltage of 13.8 kV and 27.6 kV but also owns 28 distribution stations stepping voltage down to 4.16 kV and 8.3 kV. Voltage is further stepped down in order to supply individual customers through approximately 24,000 transformers.

Horizon Utilities supports and promotes the installation of renewable generation per the Distribution System Code ("DSC") requirements. Horizon Utilities has received 54 applications since 2010, of which 24 have been successfully connected.

Horizon Utilities' distribution system has sufficient capacity to accommodate the amount of forecasted renewable generation identified in section 4(b) below.

Historically, connection costs are covered by the customer through capital contributions. Horizon Utilities accounts for all up-stream enhancement costs only after a project has been connected. Only one of the 54 projects to date involved upstream enhancement work. The amount spent for this enhancement work on this one project was not material (less than \$10,000).

Based on the foregoing, Horizon Utilities does not forecast any REG investments will be required over the 5 year period.

#### 2. REG and the Regional Planning Process (5.1.4.1)

Horizon Utilities uses an integrated approach to planning which includes all categories of investments: system renewal, system access, system service, general plant, renewable generation connection and regional planning requirements. This integrated approach optimizes investments that support the outcomes identified by the Board.

The DS Plan Filing Requirements are intended to ensure that, among other things, the Board's expectations for the optimization of investments reflect regional considerations. The Board also made amendments to the DSC such that distributors would be required to request one of three documents from the lead transmitter: a regional infrastructure plan; a letter regarding the status

of the regional infrastructure plan; or a Needs Assessment Report (where participation in a regional planning process is not required).

Horizon Utilities service area falls into two Regional Planning areas: Burlington to Nanticoke and Niagara. Horizon Utilities requested a letter from Hydro One Networks Inc. ("Hydro One") confirming the status of regional planning for the two Regional Planning areas of which Horizon Utilities is a part.

Horizon Utilities has been working with the OPA and Hydro One with respect to Regional Planning for the Burlington to Nanticoke region. Horizon Utilities has completed Hydro One's requests for information on system loading and generation to complete the 'Needs Screening' assessment for the Burlington to Nanticoke region. Most recently, Horizon Utilities' hosted a Hydro One Regional Planning meeting at the Horizon Utility facilities on January 31, 2014.

Hydro One has not initiated the Needs Screening phase for the Niagara region; this is anticipated for 2016-2017. Horizon Utilities will support the Regional Planning process for the Niagara region once these meetings commence.

Horizon Utilities actively participates with regional distributors, the IESO and Hydro One at an operational level and looks forward to participating at the regional planning level as well. The following distributors are located adjacent to Horizon Utilities' service areas:

City Of Hamilton service area:

- Burlington Hydro
- Grimsby Power Incorporated
- Hydro One Networks Incorporated ("Hydro One")
- Niagara Peninsula Energy Incorporated

City of St. Catharines service area:

- Hydro One Networks Incorporated ("Hydro One")
- Niagara-On-The-Lake Hydro Inc.
- Niagara Peninsula Energy Incorporated

Horizon Utilities has multiple connection points with Hydro One and meets with them regularly to discuss regional issues. In comparison among the remaining adjacent distributors, Horizon Utilities only has 1 connection point. Any project that arises along the borders are discussed and planned with the neighbouring distributor as it arises. Consequently, regular meetings are not required, particularly due to the small number of interconnections.

#### 3. REG and the capital expenditure planning process (5.4.2)

Horizon Utilities plans its distribution system investments to accommodate the connection of potential future renewable generation during the design phase of any project. Capital investments related to the accommodation of REG investments are project specific and are recovered through capital contributions.

Horizon Utilities' capital planning objectives, including its objective for accommodating the connection of renewable generation facilities, are to connect 100% of renewable generation where possible.

These objectives relate to Horizon Utilities' asset management objectives as described in Section 2.1.1 of the DSP. Both REG investments and Conservation and Demand Management projects are potential options for solutions to system capacity constraints during system planning.

Horizon Utilities' planning criteria and assumptions used in connection with its outlook for accommodating the connection of renewable generation facilities are as follows. Horizon Utilities considers the average number of renewable connections per year and size of the connection installed on a historical basis in order to prepare a forecast of future renewable connections.

Horizon Utilities' method and criteria used to prioritize REG investments in accordance with the planned development of the system are similar to its approach to the treatment of load customers. All necessary investments are seen as non-discretionary and are planned and designed in accordance with Horizon Utilities' standard process

Horizon Utilities does not plan to connect any distributor-owned renewable generation project(s) during the forecast period. Horizon Utilities does not own distributor-owned generation directly. Horizon Utilities owns a 99.9% interest in Solar Sunbelt General Partnership (SSGP), a general

partnership that undertakes solar photovoltaic ("PV") projects. The methodology used for the prioritization of REG investments related to SSGP is the same as that which is used for all other REG investments.

## 4. System capability assessment for REG (5.4.3)

The estimated capability of Horizon Utilities' distribution system to accommodate renewable energy generation connections at each transformer station is shown in Table 5 below.

Horizon Utilities is not aware of specific network locations where constraints are expected to emerge due to forecast changes in load and/or connected renewable generation capacity.

## (a) Applications for REG (5.4.3 (a))

A list of all of the submitted Customer Impact Assessment ("CIA") applications for renewable generation projects over 10kW is provided in Table 1. Horizon Utilities has 24 connected rooftop solar FIT applications, 16 are currently in construction and 2 had been denied as of January 28, 2014. The two projects were denied from different reasons. The first project was denied due to minimal loading on the feeder; specifically it did not comply with Institute of Electricians and Electronics Engineers (IEEE) 1547 requirements (generation must not exceed 33% of the minimum feeder load). The second project was denied due to a lack of available capacity at the Hydro One Nebo Transformer Station. The remaining applications are in process; a detailed status of each application is provided in Table 1: List of CIA Applications, below.

**Table 1: List of CIA Applications** 

| CIA# | CIA Agreement<br>(Execution date) | Generation Type  | Status       | Station | Bus  | Feeder | Project<br>Size (kW) |
|------|-----------------------------------|------------------|--------------|---------|------|--------|----------------------|
| 1    | Monday,<br>November 15,<br>2010   | Rooftop Solar PV | Connected    | Newton  | В    | 232X   | 100                  |
| 2    | Monday,<br>November 15,<br>2010   | Rooftop Solar PV | Connected    | Newton  | В    | 232X   | 175                  |
| 3    | Tuesday, March<br>15, 2011        | Rooftop Solar PV | Connected    | Nebo    | QJ   | 3631X  | 70                   |
| 4    | Tuesday, March<br>15, 2011        | Rooftop Solar PV | Connected    | Nebo    | QJ   | 3631X  | 70                   |
| 5    | Thursday, May<br>23, 2013         | Rooftop Solar PV | Construction | Lake    | J1J2 | 1412X  | 250                  |
| 6    | Thursday, August<br>04, 2011      | Rooftop Solar PV | Connected    | Dundas  | JQ   | 2D12X  | 95                   |
| 7    | Wednesday,<br>August 10, 2011     | Rooftop Solar PV | Construction | Dundas  | JQ   | 2D14X  | 14                   |
| 8    | Thursday, August<br>04, 2011      | Rooftop Solar PV | Connected    | Elgin   | QJ   | 5231X  | 40                   |
| 9    | Monday, October<br>24, 2011       | Rooftop Solar PV | Connected    | Nebo    | QJ   | 3541X  | 200                  |
| 10   | Monday, October<br>24, 2011       | Rooftop Solar PV | Connected    | Winona  | JQ   | W15X   | 100                  |
| 11   | Thursday, May<br>23, 2013         | Rooftop Solar PV | CIA Issued   | Lake    | Q1Q2 | 1831X  | 250                  |
| 12   | Thursday, May<br>23, 2013         | Rooftop Solar PV | Construction | Dundas  | JQ   | 2D13X  | 250                  |
| 13   | Monday, October<br>24, 2011       | Rooftop Solar PV | Connected    | Winona  | JQ   | W14X   | 200                  |
| 14   | Monday, October<br>24, 2011       | Rooftop Solar PV | Connected    | Winona  | JQ   | W14X   | 200                  |

## Distribution System Plan Appendix E – REG Investment Plan

| CIA# | CIA Agreement<br>(Execution date)  | Generation Type  | Status       | Station    | Bus  | Feeder | Project<br>Size (kW) |
|------|------------------------------------|------------------|--------------|------------|------|--------|----------------------|
| 15   | Wednesday,<br>November 30,<br>2011 | Rooftop Solar PV | Connected    | Winona     | JQ   | W14X   | 125                  |
| 16   | Wednesday,<br>November 30,<br>2011 | Rooftop Solar PV | Connected    | Winona     | JQ   | W14X   | 125                  |
| 17   | Wednesday,<br>November 16,<br>2011 | Rooftop Solar PV | Construction | Lake       | J1J2 | 1411X  | 100                  |
| 18   | Wednesday,<br>November 16,<br>2011 | Rooftop Solar PV | Construction | Lake       | J1J2 | 1411X  | 50                   |
| 19   | Monday, October<br>24, 2011        | Rooftop Solar PV | Connected    | Birmingham | g    | 50x81  | 250                  |
| 20   | Wednesday,<br>December 07,<br>2011 | Rooftop Solar PV | Connected    | Vansickle  | JQ   | VSM72  | 250                  |
| 21   | Monday, January<br>30, 2012        | Rooftop Solar PV | Connected    | Carlton    | ВҮ   | CTM21  | 125                  |
| 22   | Monday, October<br>24, 2011        | Rooftop Solar PV | Connected    | Newton     | В    | 282X   | 250                  |
| 23   | Thursday, May<br>23, 2013          | Rooftop Solar PV | Construction | Carlton    | НК   | CMT18  | 250                  |
| 24   | Monday, January<br>30, 2012        | Rooftop Solar PV | Connected    | Glendale   | DQ   | GLM5   | 250                  |
| 25   | Monday, January<br>30, 2012        | Rooftop Solar PV | Connected    | Bunting    | Q1Q2 | BUM82  | 108                  |
| 26   | Tuesday,<br>November 20,<br>2012   | Rooftop Solar PV | Connected    | Vansickle  | BY   | VSM52  | 65                   |
| 30   | Tuesday, April 17,<br>2012         | Rooftop Solar PV | Connected    | Lake       | J1J2 | 1411X  | 70                   |
| 29   | Tuesday, April 17,<br>2012         | Rooftop Solar PV | Connected    | Vansickle  | JQ   | VSM72  | 100                  |

## Distribution System Plan Appendix E – REG Investment Plan

| CIA# | CIA Agreement<br>(Execution date) | Generation Type   | Status            | Station   | Bus  | Feeder | Project<br>Size (kW) |
|------|-----------------------------------|-------------------|-------------------|-----------|------|--------|----------------------|
| 30   | Tuesday, April 17,<br>2012        | Rooftop Solar PV  | Construction      | Nebo      | QJ   | 3521X  | 250                  |
| 31   | Tuesday, April 17,<br>2012        | Rooftop Solar PV  | Construction      | Dundas    | JQ   | 2D12X  | 250                  |
| 32   | Tuesday, April 17,<br>2012        | Rooftop Solar PV  | Connected         | Dundas    | JQ   | 2D12X  | 250                  |
| 33   | Friday, August 03,<br>2012        | Rooftop Solar PV  | Connection Denied | Stirton   | QJ   | 8511X  | 250                  |
| 34   | Tuesday, May 15,<br>2012          | Rooftop Solar PV  | Connected         | Lake      | J1J2 | 1411X  | 100                  |
| 35   | Tuesday, June<br>19, 2012         | Load Displacement | Waiting for OPA   | Beach     |      | M42    | 8120                 |
| 36   | Tuesday, May 29,<br>2012          | Rooftop Solar PV  | Connected         | Winona    | JQ   | W14X   | 250                  |
| 37   | Tuesday,<br>November 13,<br>2012  | Rooftop Solar PV  | Construction      | Vansickle | JQ   | VSM72  | 250                  |
| 38   | Wednesday, May<br>08, 2013        | Rooftop Solar PV  | Offer to connect  | Lake      | Q1Q2 | 1811X  | 100                  |
| 39   | Wednesday, May<br>08, 2013        | Rooftop Solar PV  | Construction      | Beach     | Q2Q1 | 7321X  | 100                  |
| 40   | Wednesday, May<br>08, 2013        | Rooftop Solar PV  | Construction      | Lake      | Q1Q2 | 1811X  | 70                   |
| 41   | Friday, May 03,<br>2013           | Rooftop Solar PV  | Construction      | Carlton   | НК   | CTM18  | 250                  |
| 42   | Friday, May 03,<br>2013           | Rooftop Solar PV  | Construction      | Vansickle | JQ   | VSM72  | 250                  |
| 43   | Friday, May 03,<br>2013           | Rooftop Solar PV  | Construction      | Beach     | Q2Q1 | 7321X  | 250                  |

| CIA# | CIA Agreement<br>(Execution date) | Generation Type  | Status            | Station  | Bus  | Feeder | Project<br>Size (kW) |
|------|-----------------------------------|------------------|-------------------|----------|------|--------|----------------------|
| 44   | Thursday, May<br>23, 2013         | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1731X  | 40                   |
| 45   | Thursday, May<br>23, 2013         | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1731X  | 70                   |
| 46   | Thursday, May<br>23, 2013         | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1731X  | 70                   |
| 47   | Thursday, May<br>23, 2013         | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1731X  | 70                   |
| 48   | Friday, June 14,<br>2013          | Rooftop Solar PV | Construction      | Glendale | DQ   | GLM8   | 250                  |
| 49   | Friday, June 14,<br>2013          | Rooftop Solar PV | CIA               | Bunting  | Q1Q2 | BUM82  | 250                  |
| 50   | Friday, June 14,<br>2013          | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1731X  | 70                   |
| 51   | Friday, June 14,<br>2013          | Rooftop Solar PV | Offer to connect  | Lake     | Q1Q2 | 1811X  | 70                   |
| 52   | Friday, July 19,<br>2013          | Rooftop Solar PV | Connection Denied | Nebo     | BY   | 341X   | 150                  |
| 53   | Thursday, July 25,<br>2013        | Rooftop Solar PV | Construction      | Dundas   | BY   | 2D12X  | 250                  |
| 54   | Friday, November<br>15, 2013      | Rooftop Solar PV | Conducting CIA    | Lake     | Q1Q2 | 1722X  | 500                  |

## (b) Anticipated REG over Forecast Period (5.4.3(b))

Horizon Utilities understands that the OPA has received a total of 66 FIT Applications for Horizon Utilities' service area since the launch of the FIT Program in 2009, of which 58 have received FIT Contracts.

As described in subsection (a) above, Horizon Utilities has received 54 CIA applications. Horizon Utilities expects the balance of the 58 contracts awarded to be received in 2014. Horizon Utilities' expectations for the number of connected projects per year for each year of the forecast period is an average of 3 applications in Hamilton and 1 application in St. Catharines; more generally, the values may range between 2-4 applications in Hamilton and 0-2 applications in St. Catharines. These forecasts are based on existing applications, information available from the OPA and trending over the period seen in Tables 2 and 3, below. Horizon Utilities forecasts that such projects may add an average of 0.5MW of capacity in Hamilton (ranging between 0.50-0.75MW) and an average of 0.25MW of capacity in St. Catharines (ranging between 0.25-0.5MW).

**Table 2: Number of Connected Applications** 

| Number of Connected Applications Per Year |   |    |   |       |    |      |  |  |  |
|---|---|----|---|-------|----|------|--|--|--|
| 2010 2011 2012 2013 Total Average         |   |    |   |       |    |      |  |  |  |
| St. Catharines                            | 0 | 1  | 5 | 0     | 6  | 1.50 |  |  |  |
| Hamilton                                  | 2 | 12 | 4 | 0     | 18 | 4.50 |  |  |  |
|   |   | •  |   | Total | 24 | 6    |  |  |  |

**Table 3: MW Capacity of Connected Projects** 

| MW Capacity of Connected Projects Per Year |       |       |       |       |       |         |  |  |  |  |
|--|-------|-------|-------|-------|-------|---------|--|--|--|--|
|  | 2010  | 2011  | 2012  | 2013  | Total | Average |  |  |  |  |
| St. Catharines                             | 0     | 0.25  | 0.648 | 0     | 0.89  | 0.22    |  |  |  |  |
| Hamilton                                   | 0.275 | 1.725 | 0.67  | 0     | 2.67  | 0.66    |  |  |  |  |
|  |       | Total | 3.568 | 0.892 |       |         |  |  |  |  |

#### (c) Capacity of the Distribution System for REG (5.4.3(c))

In general, Horizon Utilities has sufficient of capacity to support REG connections in both Hamilton and St. Catharines. However, Horizon Utilities identifies that some feeders are constrained, as shown in Table 4. A list of available generation capacity for each individual station is identified in Table 5, below.

Table 4: 4.16kV and 8.32kV Generation Availability

| Station     | Feeder | Generation<br>Capacity<br>(kVA) | Existing<br>Generation<br>(A) | Existing<br>Generation<br>(kVA) | Available<br>Generation<br>Capacity<br>(A) | Available<br>Generation<br>Capacity (kW) |
|-------------|--------|---------------------------------|-------------------------------|---------------------------------|--|--|
| Aberdeen    | AB-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Aberdeen    | AB-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Aberdeen    | AB-3   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Aberdeen    | AB-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Aberdeen    | AB-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Aberdeen    | AB-6   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Baldwin     | BD-1   | 2418.59                         | 0.00                          | 0.00                            | 336.00                                     | 2176.73                                  |
| Baldwin     | BD-2   | 2418.59                         | 0.00                          | 0.00                            | 336.00                                     | 2176.73                                  |
| Bartonville | BA-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Bartonville | BA-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Bartonville | BA-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Bartonville | BA-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Bartonville | BA-5   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Bartonville | BA-6   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Bartonville | BA-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Caroline    | CA-2   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Caroline    | CA-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Caroline    | CA-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Caroline    | CA-5   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Caroline    | CA-6   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Caroline    | CA-7   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Caroline    | CA-8   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Central     | CE-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-9   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Central     | CE-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Central     | CE-11  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Cope        | CP-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Deerhurst   | DH-1   | 2738.03                         | 0.00                          | 0.00                            | 190.00                                     | 2464.22                                  |
| Deerhurst   | DH-2   | 2738.03                         | 0.00                          | 0.00                            | 190.00                                     | 2464.22                                  |

| Station    | Feeder | Generation<br>Capacity<br>(kVA) | Existing<br>Generation<br>(A) | Existing<br>Generation<br>(kVA) | Available<br>Generation<br>Capacity<br>(A) | Available<br>Generation<br>Capacity (kW) |
|------------|--------|---------------------------------|-------------------------------|---------------------------------|--|--|
| Deerhurst  | DH-3   | 2738.03                         | 0.00                          | 0.00                            | 190.00                                     | 2464.22                                  |
| Dewitt     | DW-1   | 4837.18                         | 0.00                          | 0.00                            | 336.00                                     | 4353.46                                  |
| Dewitt     | DW-2   | 4837.18                         | 0.00                          | 0.00                            | 336.00                                     | 4353.46                                  |
| Dewitt     | DW-3   | 4837.18                         | 0.00                          | 0.00                            | 336.00                                     | 4353.46                                  |
| Eastmount  | EA-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Eastmount  | EA-11  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-5   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Elmwood    | EL-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Elmwood    | EL-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Galbraith  | GA-1   | 1916.62                         | 0.00                          | 0.00                            | 133.00                                     | 1724.96                                  |
| Galbraith  | GA-2   | 1916.62                         | 0.00                          | 0.00                            | 133.00                                     | 1724.96                                  |
| Galbraith  | GA-3   | 1916.62                         | 0.00                          | 0.00                            | 133.00                                     | 1724.96                                  |
| Highland   | HI-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Highland   | HI-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Highland   | HI-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Hughson    | HU-2   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-4   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-5   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-6   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-7   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-8   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-9   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-10  | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-11  | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Hughson    | HU-12  | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| John       | JN-1   | 2418.59                         | 0.00                          | 0.00                            | 336.00                                     | 2176.73                                  |
| John       | JN-2   | 2418.59                         | 0.00                          | 0.00                            | 336.00                                     | 2176.73                                  |
| Kenilworth | KE-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Kenilworth | KE-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Kenilworth | KE-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |

| Station    | Feeder | Generation<br>Capacity<br>(kVA) | Existing<br>Generation<br>(A) | Existing<br>Generation<br>(kVA) | Available<br>Generation<br>Capacity<br>(A) | Available<br>Generation<br>Capacity (kW) |
|------------|--------|---------------------------------|-------------------------------|---------------------------------|--|--|
| Kenilworth | KE-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Kenilworth | KE-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Kenilworth | KE-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mohawk     | MK-11  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Mountain   | MT-11  | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Ottawa     | OT-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-6   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Ottawa     | OT-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Ottawa     | OT-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F1  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F2  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F3  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F4  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F5  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F6  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F7  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Parkdale   | PA-F8  | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Spadina    | SP-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Spadina    | SP-7   | 0.00                            | 0.00                          | 0.00                            | 0.00                                       | 0.00                                     |
| Strouds    | ST-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |

| Station    | Feeder | Generation<br>Capacity<br>(kVA) | Existing<br>Generation<br>(A) | Existing<br>Generation<br>(kVA) | Available<br>Generation<br>Capacity<br>(A) | Available<br>Generation<br>Capacity (kW) |
|------------|--------|---------------------------------|-------------------------------|---------------------------------|--|--|
| Strouds    | ST-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Strouds    | ST-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Strouds    | ST-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Strouds    | ST-7   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Webster    |        |                                 |                               |                                 |  | 0.00                                     |
| Wellington | WL-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wellington | WL-11  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-8   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-9   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-10  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-11  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Wentworth  | WT-12  | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-1   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-2   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-3   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-4   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-5   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| Whitney    | WH-6   | 1369.01                         | 0.00                          | 0.00                            | 190.00                                     | 1232.11                                  |
| York       | YK-1   | 2418.59                         | 0.00                          | 0.00                            | 336.00                                     | 2176.73                                  |
| York       | YK-2   | 1232.11                         | 0.00                          | 0.00                            | 171.00                                     | 1108.90                                  |

Table 5: 13.8kV and 27.6kV Generation Availability

| Station | Bus  | Breaker | Feeder | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|---------|------|---------|--------|---------|---------------------------------|---------------------------------|--|
| Beach   | B1B2 | M11     | 7111SC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M12     | 7121SC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M13     | 7131CW | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M14     | 7141F  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M14     | 7142F  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M21     | 7211F  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M21     | 7212F  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M22     | 7222CW | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M23     | 7231SC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | B1B2 | M24     | 7241SC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M51     | 7511P  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M52     | 7521X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M53     | 7531X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M53     | 7532OL | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M54     | 7541SC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M54     | 7542PE | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M61     | 7611X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M62     | 7621X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M62     | 7622IM | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M63     | 7631X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Y1Y2 | M64     | 7641P  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M71     | 7711DF | 13.86   | 0.00                            | 0.00                            | 0.00                                     |
| Beach   | J1J2 | M71     | 7712DF | 13.86   | 0.00                            | 0.00                            | 0.00                                     |
| Beach   | J1J2 | M72     | 7722X  | 13.86   | 4.56                            | 1.25                            | 2.98                                     |
| Beach   | J1J2 | M73     | 7731X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M74     | 7741S  | 13.86   | 4.56                            | 2.00                            | 2.31                                     |
| Beach   | J1J2 | M74     | 7742X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M81     | 7811DF | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M81     | 7812X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M82     | 7821X  | 13.86   | 4.56                            | 1.25                            | 2.98                                     |
| Beach   | J1J2 | M82     | 7822X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M83     | 7831BP | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M83     | 7832X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | J1J2 | M84     | 7841S  | 13.86   | 4.56                            | 2.00                            | 2.31                                     |
| Beach   | J1J2 | M84     | 7842X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M31     | 7311B  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M32     | 7321X  | 13.86   | 4.56                            | 0.35                            | 3.79                                     |
| Beach   | Q1Q2 | M33     | 7331CP | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M34     | 7341X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M34     | 7342X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M41     | 7411X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach   | Q1Q2 | M42     | 7421X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |

| Station    | Bus  | Breaker | Feeder  | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|------------|------|---------|---------|---------|---------------------------------|---------------------------------|--|
| Beach      | Q1Q2 | M43     | 7431CP  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach      | Q1Q2 | M43     | 7432X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Beach      | Q1Q2 | M44     | 7441X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | BY   | M21     | 50L21   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | BY   | M22     | 50L22   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | QJ   | M3      | 50X32   | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Birmingham | QJ   | M1      | 50B12   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M1      | 50PG11  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M2      | 50PG21  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M2      | 50X22   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M4      | 50X41   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M4      | 50X42   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M5      | 50X51   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M5      | 50X52   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M6      | 50X61   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M7      | 50X71   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Birmingham | QJ   | M8      | 50X81   | 13.86   | 4.56                            | 0.25                            | 3.88                                     |
| Birmingham | DK   | M71     | 50L71   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | DK   | M81     | 50L81   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | EZ   | M10     | 50DC101 | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | EZ   | M11     | 50L11   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Birmingham | EZ   | M14     | 50L14   | 13.86   | 19.77                           | 0.00                            | 17.79                                    |
| Dundas     | BY   | M6      | 2D6X    | 27.60   | 16.05                           | 0.00                            | 14.44                                    |
| Dundas     | BY   | M7      | 2D7X    | 27.60   | 16.05                           | 0.00                            | 14.44                                    |
| Dundas     | BY   | M1      | 2D1X    | 27.60   | 22.10                           | 0.00                            | 19.89                                    |
| Dundas     | BY   | M2      | 2D2X    | 27.60   | 22.10                           | 0.00                            | 19.89                                    |
| Dundas     | QJ   | M11     | 2D11X   | 27.60   | 17.14                           | 0.00                            | 15.42                                    |
| Dundas     | QJ   | M12     | 2D12X   | 27.60   | 17.14                           | 0.85                            | 14.66                                    |
| Dundas     | QJ   | M13     | 2D13X   | 27.60   | 17.14                           | 0.25                            | 15.20                                    |
| Dundas     | QJ   | M14     | 2D14X   | 27.60   | 17.14                           | 0.01                            | 15.41                                    |
| Elgin      | DK   | M41     | 5411X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M41     | 5412X   | 13.86   | 4.56                            | 1.00                            | 3.21                                     |
| Elgin      | DK   | M42     | 5421X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M42     | 5422X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M43     | 5431X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M44     | 5441X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M44     | 5442X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M45     | 5451X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M45     | 5452X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M46     | 5461X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M46     | 5462BC  | 13.86   | 4.56                            | 1.00                            | 3.21                                     |
| Elgin      | DK   | M47     | 5471C   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M47     | 5472X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin      | DK   | M48     | 5481X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |

| Station | Bus | Breaker | Feeder | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|---------|-----|---------|--------|---------|---------------------------------|---------------------------------|--|
| Elgin   | QJ  | M22     | 5221C  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M23     | 5231X  | 13.86   | 3.80                            | 0.04                            | 3.39                                     |
| Elgin   | QJ  | M24     | 5241CU | 13.86   | 4.56                            | 4.38                            | 0.17                                     |
| Elgin   | QJ  | M25     | 5251X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M26     | 5261X  | 13.86   | 4.56                            | 4.38                            | 0.17                                     |
| Elgin   | QJ  | M27     | 5271X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M28     | 5281X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M30     | 5301X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M31     | 5311CU | 13.86   | 4.56                            | 4.38                            | 0.17                                     |
| Elgin   | QJ  | M32     | 5321X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M33     | 5331X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | QJ  | M34     | 5341X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M51     | 5511X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M51     | 5512HG | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M52     | 5521X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M52     | 5522X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M53     | 5531SJ | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M53     | 5532SJ | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M61     | 5611X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M61     | 5612X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M62     | 5612X  | 13.86   | 4.56                            | 6.56                            | -1.80                                    |
| Elgin   | EZ  | M62     | 5622X  | 13.86   | 4.56                            | 6.56                            | -1.80                                    |
| Elgin   | EZ  | M63     | 5631X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Elgin   | EZ  | M63     | 5632X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Gage    | ZY  | M13     | M13    | 13.86   | 8.36                            | 0.00                            | 7.53                                     |
| Gage    | ZY  | M15     | M15    | 13.86   | 11.40                           | 0.00                            | 10.26                                    |
| Gage    | ZY  | M16     | M16    | 13.86   | 11.40                           | 0.00                            | 10.26                                    |
| Gage    | ZY  | M17     | M17    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | ZY  | M19     | M19    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | ZY  | M20     | M20    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | DJ  | M23     | M23    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | DJ  | M24     | M24    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | DJ  | M26     | M26    | 13.86   | 15.20                           | 0.00                            | 13.68                                    |
| Gage    | DJ  | M27     | M27    | 13.86   | 22.81                           | 0.00                            | 20.53                                    |
| Gage    | KE  | M37     | M37    | 13.86   | 7.60                            | 0.00                            | 6.84                                     |
| Gage    | KE  | M38     | M38    | 13.86   | 7.60                            | 0.00                            | 6.84                                     |
| Gage    | KE  | M32     | M32    | 13.86   | 11.40                           | 0.00                            | 10.26                                    |
| Gage    | KE  | M33     | M33    | 13.86   | 11.40                           | 0.00                            | 10.26                                    |
| Gage    | KE  | M35     | M35    | 13.86   | 12.16                           | 0.00                            | 10.95                                    |
| Gage    | KE  | M36     | M36    | 13.86   | 12.16                           | 0.00                            | 10.95                                    |
| Gage    | KE  | M34     | M34    | 13.86   | 13.68                           | 0.00                            | 12.32                                    |
| Gage    | KE  | M39     | M39    | 13.86   | 13.68                           | 0.00                            | 12.32                                    |
| Gage    | KE  | M40     | M40    | 13.86   | 13.68                           | 0.00                            | 12.32                                    |
| Gage    | KE  | M31     | M31    | 13.86   | 18.25                           | 0.00                            | 16.42                                    |

| Station    | Bus  | Breaker | Feeder    | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|------------|------|---------|-----------|---------|---------------------------------|---------------------------------|--|
| Horning    | B1B2 | M2      | 421X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M3      | 431X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M4      | 441X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M5      | 451X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M6      | 461EL     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M6      | 462X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M7      | 471X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M8      | 481X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M9      | 491X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M9      | 492X      | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M10     | 4101X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M10     | 4102X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | B1B2 | M11     | 4111X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M45     | 4451X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M46     | 4461X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M46     | 4462SJ    | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M47     | 4471X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M48     | 4481X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M49     | 4491X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Horning    | Q1Q2 | M50     | 4501X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | DK   | Decomi  | missioned | 13.86   | 13.86                           | 0.00                            | 0.00                                     |
| Kenilworth | EJ   | M20     | 92010     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M21     | 92110     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M22     | 9221K     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M23     | 9231K     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M25     | 9251N     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M26     | 9261N     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M27     | 9271X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M27     | 9281X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M29     | 9291X     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | EJ   | M30     | 9301N     | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Kenilworth | BY   | M54     | M54       | 13.86   | 9.12                            | 0.00                            | 8.21                                     |
| Kenilworth | BY   | M64     | M64       | 13.86   | 9.12                            | 0.00                            | 8.21                                     |
| Kenilworth | BY   | M51     | M51       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Kenilworth | BY   | M52     | M52       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Kenilworth | BY   | M53     | M53       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Kenilworth | BY   | M61     | M61       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Kenilworth | BY   | M62     | M62       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Kenilworth | BY   | M63     | M63       | 13.86   | 18.25                           | 0.00                            | 16.42                                    |
| Lake       | BY   | M1      | 111X      | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Lake       | BY   | M2      | 121X      | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Lake       | BY   | М3      | 131X      | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Lake       | BY   | M4      | 141X      | 27.60   | 19.07                           | 0.00                            | 17.17                                    |

| Station | Bus  | Breaker | Feeder | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|---------|------|---------|--------|---------|---------------------------------|---------------------------------|--|
| Lake    | BY   | M5      | 151X   | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Lake    | BY   | M6      | 161X   | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Lake    | J1J2 | M31     | 1311X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | J1J2 | M32     | 1321X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | J1J2 | M33     | 1331X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | J1J2 | M41     | 1411X  | 13.86   | 4.56                            | 0.32                            | 3.82                                     |
| Lake    | J1J2 | M41     | 1412X  | 13.86   | 4.56                            | 0.25                            | 3.88                                     |
| Lake    | J1J2 | M42     | 1421X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | J1J2 | M42     | 1422X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | J1J2 | M43     | 1431X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M71     | 1711X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M71     | 1712X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M72     | 1721X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M72     | 1722X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M73     | 1731X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M81     | 1811X  | 13.86   | 4.56                            | 0.07                            | 4.04                                     |
| Lake    | Q1Q2 | M81     | 1812X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M82     | 1821X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M82     | 1822X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M83     | 1831X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Lake    | Q1Q2 | M83     | 1832X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M51     | 0511X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M51     | 0512X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M52     | 0521EA | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M52     | 0522WL | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M53     | 0531X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M53     | 0532X  | 13.86   | 4.56                            | 1.01                            | 3.19                                     |
| Mohawk  | B1B2 | M61     | 0611X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M61     | 0612X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M62     | 0621LM | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M62     | 0622X  | 13.86   | 4.56                            | 1.01                            | 3.19                                     |
| Mohawk  | B1B2 | M63     | 0631WL | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M63     | 0632MK | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M64     | 0641X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | B1B2 | M64     | 0642X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M71     | 0711X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M71     | 0712WL | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M72     | 0721X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M72     | 0722X  | 13.86   | 4.56                            | 1.01                            | 3.19                                     |
| Mohawk  | Y1Y2 | M73     | 0731X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M73     | 0732EA | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M81     | 0811MK | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M81     | 0812X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M82     | 0821X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |

| Station | Bus  | Breaker | Feeder | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|---------|------|---------|--------|---------|---------------------------------|---------------------------------|--|
| Mohawk  | Y1Y2 | M82     | 0822WL | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M83     | 0831M  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Mohawk  | Y1Y2 | M83     | 0832X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | BY   | M3      | 331X   | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Nebo    | BY   | M4      | 341X   | 27.60   | 19.07                           | 0.00                            | 17.17                                    |
| Nebo    | QJ   | M51     | 3511X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M51     | 3512X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M52     | 3521X  | 13.86   | 4.56                            | 0.25                            | 3.88                                     |
| Nebo    | QJ   | M53     | 3531X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M53     | 3532X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M54     | 3541X  | 13.86   | 4.56                            | 0.20                            | 3.93                                     |
| Nebo    | QJ   | M61     | 3611X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M61     | 3612X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M62     | 3621X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M63     | 3631X  | 13.86   | 4.56                            | 0.14                            | 3.98                                     |
| Nebo    | QJ   | M63     | 3632X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M64     | 3641X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Nebo    | QJ   | M64     | 3642X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | M1      | 211SL  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | M1      | 212X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | М3      | 231X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | М3      | 232X   | 13.86   | 4.56                            | 0.28                            | 3.86                                     |
| Newton  | В    | M6      | 261SL  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | M6      | 262X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | M8      | 281X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | В    | M8      | 282X   | 13.86   | 4.56                            | 0.25                            | 3.88                                     |
| Newton  | В    | M10     | 2101C  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M2      | 221CA  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M2      | 222X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M4      | 241X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M4      | 242X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M5      | 251A   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M5      | 252X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M7      | 271X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M9      | 291X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Newton  | Υ    | M9      | 292X   | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY   | M71     | 8711X  | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Stirton | BY   | M72     | 8721X  | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Stirton | BY   | M76     | 8762G  | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Stirton | BY   | M83     | 8832X  | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Stirton | BY   | M85     | 8852X  | 13.86   | 3.80                            | 0.00                            | 3.42                                     |
| Stirton | BY   | M71     | 8712W  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY   | M72     | 8722W  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY   | M75     | 8751WC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |

| Station | Bus | Breaker | Feeder | Voltage | Generation<br>Capacity<br>(MVA) | Existing<br>Generation<br>(MVA) | Available<br>Generation<br>Capacity (MW) |
|---------|-----|---------|--------|---------|---------------------------------|---------------------------------|--|
| Stirton | BY  | M81     | 8811X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY  | M82     | 8821DG | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY  | M83     | 8831W  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY  | M84     | 8841W  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY  | M84     | 8842X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | BY  | M86     | 8862X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M51     | 8511X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M62     | 8621X  | 13.86   | 3.80                            | 8.75                            | -4.45                                    |
| Stirton | QZ  | M52     | 8521S  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M53     | 8531S  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M54     | 8541X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M54     | 8542X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M61     | 8611S  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M63     | 8631X  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M64     | 8641S  | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Stirton | QZ  | M64     | 8642WC | 13.86   | 4.56                            | 0.00                            | 4.11                                     |
| Winona  | QJ  | M11     | W11X   | 27.60   | 17.14                           | 0.00                            | 15.42                                    |
| Winona  | QJ  | M12     | W12X   | 27.60   | 17.14                           | 2.36                            | 13.30                                    |
| Winona  | QJ  | M13     | W13X   | 27.60   | 17.14                           | 0.00                            | 15.42                                    |
| Winona  | QJ  | M14     | W14X   | 27.60   | 17.14                           | 0.90                            | 14.61                                    |
| Winona  | QJ  | M15     | W15X   | 27.60   | 17.14                           | 0.10                            | 15.33                                    |
| Winona  | QJ  | M16     | W16X   | 27.60   | 17.14                           | 0.00                            | 15.42                                    |

## (d) System Constraints (5.4.3(d))

Horizon Utilities has three feeders which are constrained due to the presence of existing generation. These generators cause a minimum loading constraint on these feeders. More load would have to be added to the feeders by the addition of new customers, to resolve this issue. To date, any constraints related to the connection of renewable generation caused directly by Horizon Utilities' distribution system have been due to minimal loading on feeders.

Constraints on the host transmitter, Hydro vary; the most common of these is thermal or short circuit loading. The substations in St. Catharines will be relieved when Allanburg TS breaker upgrades are completed in 2014 by Hydro One. Additional capacity for renewable generation will be available in Hamilton/Stoney Creek when the short circuit values are recalculated and the results reported on March 1, 2014 for Nebo TS (27.6kV) by Hydro One.

#### (e) Constraints for Embedded Distributor (5.4.3(e))

Horizon Utilities receives electricity from the Hydro One distribution system at certain delivery points, rather than from the IESO-controlled grid. Horizon Utilities' Hamilton service area is partially embedded in the Hydro One distribution system in the vicinities of Ancaster, Dundas, Flamborough, and Stoney Creek. These are former municipalities that now form part of the City of Hamilton following a municipal amalgamation in 2001; they are within the Horizon Utilities Hamilton service area. Horizon Utilities has no embedded distributors.

## 5. Conclusions

At this time, neither a Regional Infrastructure Plan, nor an Integrated Regional Resource Plan ("IRRP") has been initiated for the Horizon Utilities' service territory in the Niagara region.

However, within the Burlington to Nanticoke region, an IRRP is currently being developed for the Brant sub-region called the Brant IRRP. Horizon Utilities receives information and updates on regional planning for the Brant sub-region, although it has not been directly impacted by the supply issues associated with the Brant area.

As part of the regional planning process, a "Needs Screening" assessment for the Burlington to Nanticoke region has also been initiated. The OPA confirms that Horizon Utilities is actively participating in planning meetings, consultations and regional planning initiatives with the OPA, LDCs and Hydro One Networks Inc.

With respect to the OPA commenting on the consistency of planned REG Investments to regional plans, Horizon Utilities' Plan indicates that it has sufficient capacity to accommodate the amount of forecasted renewable energy generation identified in its 5-year Distribution System Plan, and that no REG investments will be required over this time period.

### Attachment A: The Board's expectations for the OPA's comment letter

On March 28, 2013, the Board issued Chapter 5 of the *Board's Filing Requirements for Electricity Transmission and Distribution Applications*, entitled *Consolidated Distribution System Plan Filing Requirements* (the "DS Plan Filing Requirements"). The Board's expectations for a letter of comment from the OPA are set out in Section 5.1.4.2 of the DS Plan Filing Requirements.

#### The OPA letter of comment will include:

- The applications it has received from renewable generators through the FIT program for connection in the distributor's service area;
- Whether the distributor has consulted with the OPA, or participated in planning meetings with the OPA;
- The potential need for co-ordination with other distributors and/or transmitters or others on implementing elements of the Renewable Energy Generation investments; and
- Whether the Renewable Energy Generation investments proposed in the DS Plan are consistent with any Regional Infrastructure Plan.

The Board identified in its DS Plan Filing Requirements that it may postpone processing an application where a comment letter from the OPA has not been filed in accordance with this requirement.

### **Attachment B: OPA Letter**

**OPA Letter of Comment** 

Horizon Utilities Corporation

Renewable Energy
Generation Investments Plan















#### Introduction

On March 28, 2013, the Ontario Energy Board ("the OEB" or "Board") issued its Filing Requirements for Electricity Transmission and Distribution Applications; Chapter 5 – Consolidated Distribution System Plan Filing Requirements (EB-2010-0377). Chapter 5 implements the Board's policy direction on 'an integrated approach to distribution network planning', outlined in the Board's October 18, 2012 Report of the Board - A Renewed Regulatory Framework for Electricity Distributors: A Performance Based Approach.

As outlined in the Chapter 5 filing requirements, the Board expects that the Ontario Power Authority ("OPA") comment letter will include:

- the applications it has received from renewable generators through the FIT program for connection in the distributor's service area;
- whether the distributor has consulted with the OPA, or participated in planning meetings with the OPA:
- the potential need for co-ordination with other distributors and/or transmitters or others on implementing elements of the REG investments; and
- whether the REG investments proposed in the DS Plan are consistent with any Regional Infrastructure Plan.

### Horizon Utilities Corporation. – Distribution System Plan

On February 12, 2014 Horizon Utilities Corporation ("Horizon Utilities") provided the OPA with Appendix E – Renewable Energy Generation Investment Plan ("Plan"), which is part of its overall 5-year Distribution System Plan. The OPA has reviewed Horizon Utilities' Plan and has provided its comments below.

#### OPA FIT/microFIT Applications Received

In its Plan, Horizon Utilities indicates that since 2010 it has received 54 applications totalling 8,542 kW of capacity. Of these, 24 FIT projects totalling 3,568 kW of capacity have been connected to its distribution system. Horizon Utilities' Plan does not breakout the microFIT from FIT projects.

According to OPA's information, as of February 2014, the OPA has offered contracts to 58 FIT projects totalling 8,893 kW of capacity. The OPA has also offered contracts to 259 microFIT projects totalling approximately 3,096 kW of capacity in Horizon Utilities' distribution system, all of which remain active as of February 2014.

The OPA finds that Horizon Utilities' Plan is reasonably consistent with the OPA's information regarding renewable energy generation ("REG") applications to date. The slight difference in the number of applications is likely the result of different dates for data collection.

Consultation / Participation in Planning Meetings; Coordination with Distributors / Transmitters / Others; Consistency with Regional Plans

The OPA notes that Horizon Utilities is part of the "Group 1" - Burlington to Nanticoke region, and the "Group 3" - Niagara region, for regional planning purposes.

At this time, neither a Regional Infrastructure Plan, nor an Integrated Regional Resource Plan ("IRRP") has been initiated for the Horizon Utilities' service territory in the Niagara region.

However, within the Burlington to Nanticoke region, an IRRP is currently being developed for the Brant sub-region called the Brant IRRP. Horizon Utilities receives information and updates on regional planning for the Brant sub-region, although it has not been directly impacted by the supply issues associated with the Brant area.

As part of the regional planning process, a "Needs Screening" assessment for the Burlington to Nanticoke region has also been initiated. The OPA confirms that Horizon Utilities is actively participating in planning meetings, consultations and regional planning initiatives with the OPA, LDCs and Hydro One Networks Inc.

With respect to the OPA commenting on the consistency of planned REG Investments to regional plans, Horizon Utilities' Plan indicates that it has sufficient capacity to accommodate the amount of forecasted renewable energy generation identified in its 5-year Distribution System Plan, and that no REG investments will be required over this time period.

The OPA looks forward to working further with Horizon Utilities Corporation throughout the regional planning process for these areas, and appreciates the opportunity to comment on the information provided as part of its Distribution System Plan.

### Appendix F - 4kV and 8kV Renewal Program

## **Executive Summary**

Horizon Utilities Corporation ("Horizon Utilities") distributes electricity to approximately 240,000 customers in the Hamilton and St. Catharines area. Of the entire customer base, 75,000 customers are served from the 4.16 kV and 8.32 kV voltage levels. The service area where these distribution assets are located was mainly constructed in the 1950s and these assets generally have a poor or very poor health index exposing Horizon to higher risk from failures. The aging infrastructure and changing distribution system standards makes it imperative to replace these assets. Prolonging to sustain this infrastructure will result in reliability levels continuing to degrade and unnecessarily increase capital and operating costs.

The 4.16 kV and 8.32 kV systems are comprised of two main asset categories: substation class assets and distribution class assets. These assets are among the oldest assets in Horizon's service area. They are also, not surprisingly, in poor or very poor condition generally. The priority of a 4.16 kV or 8.32 kV service areas for renewal is derived by the health index rating of each of the distribution assets and the substation assets. Each of these assets has its own probability of failure, consequence for failure, and required investment to replace or renew. In some cases the substation must be renewed but the distribution assets can continue to operate for some time yet. In other cases all the assets in the area need to be addressed; distribution and substation assets alike. The eventuality however is that the 4.16 kV and 8.32 kV systems will be eliminated since these are based on older technologies, are less efficient having higher line losses, and by utilizing the higher voltages at the 13.8 kV and 27.6 kV levels one can completely avoid the need for costly municipal substations.

The 4.16 kV and 8.32 kV voltage level renewal plan outlined in Section 4 contains a specific order of suggested areas to be renewed. This area-wide renewal approach is based on asset condition of substations and the distribution system, and operating and backup capabilities within the substations that reside in these areas. The 4.16 kV and 8.32 kV areas are derived of operating "Neighborhood Clusters" wherein the substations within each area back each other up and going down a level of detail the feeders within this area also back each other up. Thus it makes inherent sense to initiate the renewal with an area-wide focus in most cases. The renewal plan has been designed in such a way so as to maintain adequate backup capability with the area at all times.

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### 1. Introduction

Horizon Utilities Corporation (Horizon Utilities) is one of the largest municipally owned electricity distribution company in Ontario. It provides electricity and related utility services to over 240,000 residential, commercial, and industrial customers in Hamilton and St. Catharines. The electricity distribution system is comprised of several voltage levels ranging from 4.16 kilovolts (kV) to a maximum of 27.6 kV.

Although the majority of the customer base in Hamilton and St. Catharines is served from the 13.8 kV and the 27.6 kV distribution voltage levels, approximately 75,000 customers are served from the 4.16 kV and 8.32 kV levels. These areas include 28 substations among which 25 are in Hamilton and 3 are in St. Catharines. In these service areas, the assets are at or nearing their end of life. This poses the threat of incurring unanticipated outages due to equipment failure and high capital expenditure levels. Renewing assets by converting these parts of the system to a higher voltage will result in lower maintenance costs, higher reliability indices, increased customer satisfaction and avoid capital and maintenance costs associated with maintaining aged substation assets. The 4.16 kV and 13.8 kV Renewal Program entails the eventual upgrade of all the distribution system assets to the higher voltage standard and the corresponding removal of load from the substations allowing them to be decommissioned.

The plan provides Horizon Utilities with a decision model to justify and prioritize capital investments in various parts of the 4.16 kV and 8.32 kV voltage service areas allowing Horizon Utilities to organize capital investments over the long term while maintaining or improving system reliability levels throughout the programs duration.

Based on the most current information available, a list of priority areas and a schedule of these investments has been outlined. Annually a detailed analysis is performed on individual feeders prior to project issuance to ensure that accelerated degradation or unexpected results have not occurred in other areas. The updated information, based on experience and heath of assets, is fed into the decision model and, if required, priorities are rearranged.

Similarly, as the Asset Management Implementation Program undergoes continuous improvements, better asset information and performance will be incorporated into the data analysis as it becomes available. This would enable better condition assessment of the assets and enable more timely investment decisions on the 4.16 kV and 8.32 kV system renewals.

### 2. Background

This 4kV and 8kV Renewal Program is a system-wide study on the 4.16 kV and 8.32 kV voltage level service areas that prioritizes capital investments required and sets out a plan regarding the decommissioning of substations in the Horizon Utilities service area.

The plan has evolved over the years as Horizon Utilities asset management plan has been revised. The original plan was initiated in 2008 using the distribution assets as the primary driver for renewal and conversion. In 2009 the plan was revised to include substation assets as part of the evaluation criteria. The following year in 2010, Horizon Utilities retained the services of AESI to perform a Substation Asset Condition Assessment (SACA) against a defined scoring methodology to benchmark the substations against. The SACA results led to the first major shift in the Renewal Plan, brought upon by the more extensive investigation of assets in the substations and observation of operational issues impacting the performance of the assets.

In 2013, Horizon Utilities retained the services of Kinectrics to perform an Asset Condition Assessment (ACA) on all major asset categories, both substation and distribution assets. The updated asset condition information has been used to update the plan, but this new information has just re-enforced the decisions made in previous years, and has had no material impact to the findings and necessity of the overall plan.

| <b>Year</b> | 4kV & 8kV Plan Modifications      |
|-------------|-----------------------------------|
| 2008        | Distribution Assets included      |
| 2009        | Substation Assets included        |
| 2010        | AESI SACA performed, plan refined |
| 2013        | Kinectrics ACA performed          |

The Renewal Plan takes many factors into consideration to formulate the order of substation renewal. The key parameters of the plan are:

- Distribution Asset Age
- Substation Asset Condition
- Distribution System Arrangement
- Feeder Dependency
- Customer Impact
- Source Availability
- Cost of renewal
- Safety and environmental risks

The assumptions used in the process of developing the Renewal Program are as follows:

• The design group will assess every feeder in detail to develop a conversion design at the time of renewal.

- The Renewal Program is developed based on a 'best utility practice' for replacement of distribution assets.
- The asset condition data is used to assist in the prioritization of substation and distribution renewal.
- If any major assets in the substations fail or load capacity increase is required, the plan is re-evaluated to justify the conversion of the whole feeder or parts of the feeder and the plan is adjusted to capture the effects of the change.
- GIS data used in the Renewal Program is reliable and where new information is available, it will be incorporated into the plan.

## 3. History and Progress

Although Horizon Utilities' created the 4kV and 8kV Renewal Program in 2009 as a result of formalizing Asset Management practices, the renewal of distribution assets to a higher voltage level and subsequent decommissioning of municipal substations has been ongoing for many years. These activities pre-date the amalgamation and formation of Horizon Utilities.

The area serviced by the following substations were renewed and converted to a higher voltage level prior to 2009:

Gibson Substation

Ferrie Substation

**Sherman Substation** 

Vineland Substation

Waterdown Substation

Watkins Substation

**Burgoyne Substation** 

Ferndale Substation

Willow Substation

From 2009 - 2013, the areas served by the following substations were renewed and converted to a higher voltage:

Halson Substation – Complete

Webster Substation – Complete

Taylor Substation – Complete

Welland Substation – 2 of 3 phases complete

Caroline Substation – 6 of 7 phases complete

Hughson Substation – 6 of 7 phases complete

Aberdeen Substation – 1 of 6 phases complete

When comparing the above list of stations to the scores found in the 2010 4kV and 8kV Renewal Program it is apparent that Horizon Utilities has been able to eliminate most of the worst scoring substation assets based on the 2009 ACA performed by AESI, which also aligned to the Kinectrics ACA completed in 2013.

The appendix contains a copy of the revised schedule for the 40 year Renewal Program. An additional phase was required for the Hughson Substation voltage conversion project due to increased complexities working in urban downtown settings. As a result of this, the Caroline Substation conversion was also delayed due to the requirement of feeder back-ups between the two stations. From the experience gained from these projects, the original estimated schedule for Central Substation has been increased from 6 years to 7 years as it features many of the same challenges observed during the Hughson project. In St. Catharines, a similar situation occurred with the Taylor Substation, where the project required an extra phase to fully complete the work.

### 4. Renewal Plan Methodology

The 4.16 kV and 8.32 kV Renewal Program outlines a recommended order of conversions to the 13.8 kV or 27.6 kV voltage level. The replacement of the 4.16 kV and 8.32 kV assets is in accordance to a logical plan – one that reduces risk by replacing assets in an order that minimizes the risk of failures due to assets with a poor health rating and minimizes investments in future capital costs of substation assets. The recommended replacement strategy uses design criteria establishes the most logical justification for undertaking conversion projects. The design criteria are utilized in the different stages of plan development to derive a detailed scoring methodology that analyzes each of the feeders. Based on this scoring methodology, the feeders are evaluated in comparison to each other leading to a final area ranking. The methodology of the renewal Program is broken down into the feeder ranking, substation condition scoring, cost analysis and feasibility analysis procedures. The criteria below are used as inputs to each of these design procedures to ultimately derive the final plan.

Following are each of the criteria and their contributions in the different stages of the design methodology procedures:

### **Distribution Asset Condition**

Upgrading the aging distribution assets is one of the main drivers behind the conversion projects in Horizon Utilities. The majority of distribution assets in the 4.16 kV and 8.32 kV voltage level service areas are past their end of life expectancies. The Security Planning process ensures that we reduce the impact of unplanned outages due to failure. Based on the demographics of the distribution assets found in the GIS, not adopting a proactive replacement strategy would result in high levels of capital expenditures and higher operating and maintenance costs as reactive replacements are more expensive than planned replacement. It is also inefficient to replace individual assets as required as large scale renewal projects optimize resources. The assets considered are transformers, poles, conductors and cables. Using the Kinectrics ACA Horizon Utilities is able to create an overall health snapshot of the feeder assets and extrapolate that information into an overall substation area ranking.

### **Substation Asset Condition**

The major assets in a distribution substation are power transformer(s), switchgear, circuit breakers, protection and control system, the station services, reclosers, and the physical facility. The substation assets are managed through extensive maintenance programs. The analyses of the maintenance results are used to assess asset condition and probability of failure. To establish the recommended year of decommissioning a substation both the Kinectrics ACA and SACA were used to derive a score for each station based on the following components: Station Services, Switchgear, Protection and Control (P&C),

Reclosers, Circuit Breakers, and Transformers. A summary of the results for each station is documented in Section 6 of this report.

### **Feeder dependency**

Horizon Utilities 4.16 kV and 8.32 kV distribution feeders are operated with a detailed contingency plan ensuring redundancy and load transfer capability in case of failure. The Horizon Utilities distribution area, when studied for backup contingencies, shows that there is an area based structure whereby a group of substations back each other up through tie points between feeders. This structure mimics a cluster-like zone that is primarily self-contained with minimal backup between adjacent areas. This prompted the development of an area-based ranking that ensures that the operability is maintained while the feeders are renewed at the higher voltage.

An analysis of feeders which have ties to adjacent substations identifies that the 28 substations remaining in the system can be organized into the following operating areas:

**Dundas** (4 stations – Baldwin, Highland, John and York)

**West Hamilton** (2 stations – Stroud's Lane, Whitney)

**Downtown Hamilton** (4 stations – Aberdeen, Hughson, Central, Caroline)

**East Hamilton** (7 stations – Bartonville, Cope, Kenilworth, Ottawa, Parkdale, Spadina, Wentworth)

**Hamilton Mountain** (5 stations – Eastmount, Elmwood, Mountain, Mohawk, Wellington)

**Stoney Creek** (3 stations – Deerhurst, Dewitt, Galbraith)

**St. Catharines** (3 stations – Grantham, Welland, Vine)

Each of these areas can be considered islanded from other operating areas as few ties exist between clusters, but contain multiple ties to other feeders within the same cluster. Accordingly, assessment of total health indices by area is useful to ensure that support from other feeders within the same operating area will be available and consequently, security of supply to all customers is retained.

### **Customer Impact**

The number of customers connected onto each feeder has been considered in the Renewal Program. The customer score has been derived by the weighted average of each customer class (i.e. commercial, industrial, and residential) per feeder. The weights used for each customer class vary based on the impact of a failure on that class of customers. The commercial customers have a higher weighting than the residential customers, and industrial customers have a higher weighting then both commercial or residential. The rationale for adopting this weighting system is that the impact of a failure to a customer is directly correlated to the value that the customer attaches to the service. Horizon Utilities refers to this impact as Value of Service (VOS), based on the metrics developed by Roy Billinton of the University of Saskatchewan. The VOS is used to quantify the effect of lost sales, lost production, lost opportunity costs, etc., and is expressed in terms of \$/kwh.

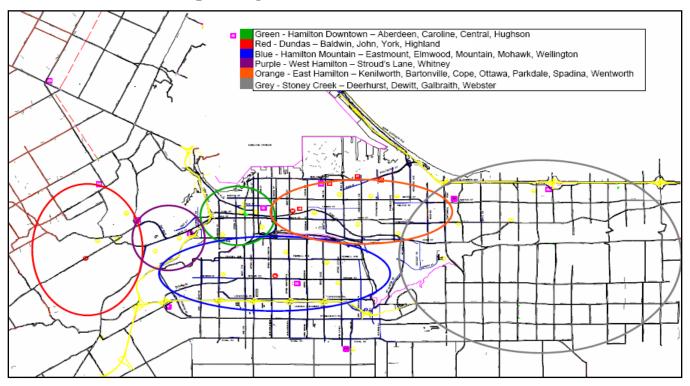
The application of the weighted customer score has been incorporated in the final Renewal Program in the distribution failure scores.

Since a renewal project would entail replacing all assets in an area, it is expected that outages caused by defective equipment will be reduced in the process. With the progress of the Smart Grid Strategy Implementation, other solutions such as installing mid-line reclosers, remote operable switches etc. will allow for quicker response and restoration times resulting in improved reliability levels.

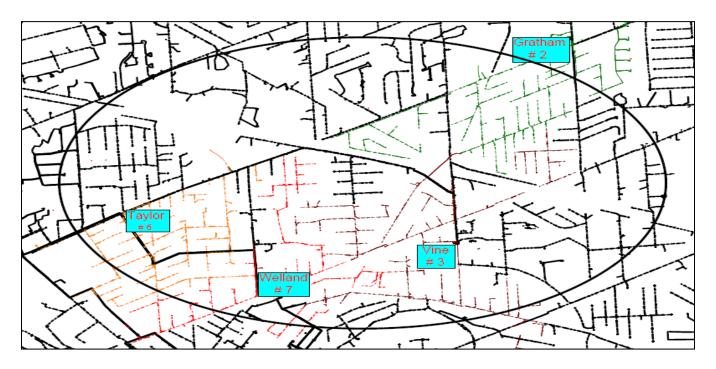
## 5. Conversion Maps – Horizon Service Area

The following pages contain the 2009 and year-end 2013 GIS Maps showing the areas served by the 4.16 kV and 8.32 kV voltage levels in the Horizon Utilities Corporation service area.

## **Hamilton Area Operating Clusters**



## St. Catharines Area Operating Cluster



## 6. Substation Assessments:

# Aberdeen

Address: 416 ABERDEEN AVENUE, HAMILTON

Facility: INDOOR S/S Year Built: 1969



### Assessment

| <u>IBBCBBIIIC</u> | Equipment Type             | Health Index | Weighting - Indoor |
|-------------------|----------------------------|--------------|--------------------|
| 1)                | Transformer                | 90%          | 25%                |
| 2)                | Breaker                    | 39%          | 20%                |
| 3)                | Reclosers                  | 0            | 0%                 |
| 4)                | Switch Gear                | 46%          | 20%                |
| 5)                | P&C                        | 35%          | 20%                |
| 6)                | Station Service            | 45%          | 5%                 |
| 7)                | Site & Civil               | 44%          | 10%                |
| 8)                | Bus, Switches & Structures | 0%           | 0%                 |
|                   | Station Health Index       | 53%          | 100%               |

| Station  | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to |
|----------|---------|--------------------------------------|--------------|
| Aberdeen | AB-1    | 197                                  | AB-2         |
| Aberdeen | AB-2    | 272                                  | AB-1         |
| Aberdeen | AB-3    | 0                                    |              |
| Aberdeen | AB-4    | 203                                  | CE-2, CE-3   |
| Aberdeen | AB-5    | 176                                  | ST-6         |
| Aberdeen | AB-6    | B.E.                                 |              |

# **Baldwin**

Address: 38 BALDWIN STREET, DUNDAS.

Facility: OUTDOOR S/S Year Built: UNKNOWN



### <u>Assessment</u>

|   | Equi     | ipment Type           | Health Index | Weighting - Outdoor |
|---|----------|-----------------------|--------------|---------------------|
|   | I) Tran  | sformer               | 93%          | 30%                 |
| : | 2) Brea  | ker                   | 0%           | 0%                  |
| ; | 3) Recl  | osers                 | 96%          | 15%                 |
|   | 4) Swite | ch Gear               | 0%           | 0%                  |
|   | 5) P&C   |                       | 67%          | 15%                 |
| ( | S) Stati | on Service            | 40%          | 5%                  |
| • | 7) Site  | & Civil               | 83%          | 10%                 |
| ; | B) Bus,  | Switches & Structures | 83%          | 25%                 |
|   | Stati    | ion Health Index      | 84%          | 100%                |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to     |
|---------|---------|--------------------------------------|------------------|
| Baldwin | BD-1    | 195                                  | BD-2, JN-1, JN-2 |
| Baldwin | BD-2    | 130                                  | BD-1, HI-2       |

## Bartonville

Address: 2355 KING STREET EAST, HAMILTON

Year Built: 1952 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 86%          | 25%                |
| 2) | Breaker                    | 100%         | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 52%          | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 10%          | 5%                 |
| 7) | Site & Civil               | 66%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 77%          | 100%               |

| Station     | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to    |
|-------------|---------|--------------------------------------|-----------------|
| Bartonville | BA-1    | 181                                  | BA-2,BA-4,PA-F3 |
| Bartonville | BA-2    | 126                                  | BA-1,KE-5       |
| Bartonville | BA-3    | 64                                   | BA-4,BA-7       |
| Bartonville | BA-4    | 218                                  | BA-1,BA-3,KE-6  |
| Bartonville | BA-5    | B.E.                                 |                 |
| Bartonville | BA-6    | B.E.                                 |                 |
| Bartonville | BA-7    | 131                                  | BA-3            |

# Caroline

Address: 117 MARKET STREET, HAMILTON

Year Built: 1955 Facility: INDOOR S/S



### <u>Assessment</u>

| <u>sessine</u> | Equipment Type             | Health Index | Weighting - Indoor |
|----------------|----------------------------|--------------|--------------------|
| 1)             | Transformer                | 86%          | 25%                |
| 2)             | Breaker                    | 51%          | 20%                |
| 3)             | Reclosers                  | 0%           | 0%                 |
| 4)             | Switch Gear                | 51%          | 20%                |
| 5)             | P&C                        | 55%          | 20%                |
| 6)             | Station Service            | 25%          | 5%                 |
| 7)             | Site & Civil               | 64%          | 10%                |
| 8)             | Bus, Switches & Structures | 0%           | 0%                 |
|                | Station Health Index       | 61%          | 100%               |

| Station  | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to |
|----------|---------|--------------------------------------|--------------|
| Caroline | CA-2    | 0                                    |              |
| Caroline | CA-3    | 122                                  | AB-2         |
| Caroline | CA-4    | 266                                  |              |
| Caroline | CA-5    | 0                                    |              |
| Caroline | CA-6    | 0                                    |              |
| Caroline | CA-7    | 53                                   | HU-12        |
| Caroline | CA-8    | B.E.                                 |              |

## Central

Address: 193 JOHN ST. SOUTH, HAMILTON

Year Built: 1950 Facility: INDOOR S/S



### <u>Assessment</u>

| BBITTE | Equipment Type             | Health Index | Weighting - Indoor |
|--------|----------------------------|--------------|--------------------|
| 1)     | Transformer                | 90%          | 25%                |
| 2)     | Breaker                    | 46%          | 20%                |
| 3)     | Reclosers                  | 0            | 0%                 |
| 4)     | Switch Gear                | 58%          | 20%                |
| 5)     | P&C                        | 30%          | 20%                |
| 6)     | Station Service            | 20%          | 5%                 |
| 7)     | Site & Civil               | 62%          | 10%                |
| 8)     | Bus, Switches & Structures | 0%           | 0%                 |
|        | Station Health Index       | 56%          | 100%               |

| <u>Dependency / Loading</u> |         |                                |              |
|-----------------------------|---------|--------------------------------|--------------|
| Station                     | Circuit | Forecasted Peak Current (Amps) | Connected to |
| Central                     | CE-1    | 82                             |              |
| Central                     | CE-2    | 140                            | CE-8         |
| Central                     | CE-3    | 146                            | CE-10.CE-8   |
| Central                     | CE-4    | 193                            | CE-5,CE-11   |
| Central                     | CE-5    | 50                             | CE-4         |
| Central                     | CE-6    | 17                             |              |
| Central                     | CE-8    | 90                             | CE-2,CE-3    |
| Central                     | CE-9    | 11                             |              |
| Central                     | CE-10   | 197                            | CE-3,MT-10   |
| Central                     | CE-11   | 141                            | CE-4         |

# Cope

Address: 1430 BARTON ST. EAST, HAMILTON

Year Built: 1965 Facility: INDOOR S/S



### <u>Assessment</u>

| CSSIIIC | Equipment Type             | Health Index | Weighting - Indoor |
|---------|----------------------------|--------------|--------------------|
| 1)      | Transformer                | 88%          | 25%                |
| 2)      | Breaker                    | 100%         | 20%                |
| 3)      | Reclosers                  | 0%           | 0%                 |
| 4)      | Switch Gear                | 71%          | 20%                |
| 5)      | P&C                        | 90%          | 20%                |
| 6)      | Station Service            | 40%          | 5%                 |
| 7)      | Site & Civil               | 82%          | 10%                |
| 8)      | Bus, Switches & Structures | 0%           | 0%                 |
|         | Station Health Index       | 84%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to     |
|---------|---------|--------------------------------------|------------------|
| Cope    | CP-1    | 141                                  | CP-9,PA-F3,KE-2  |
| Cope    | CP-2    | 214                                  | CP-8, OT-3       |
| Cope    | CP-3    | 131                                  | PA-F1, CP-4      |
| Cope    | CP-4    | 103                                  | PA-F1, CP-3,CP-7 |
| Cope    | CP-5    | 131                                  | CP-6,OT-2,OT-5   |
| Cope    | CP-6    | 86                                   | CP-5             |
| Cope    | CP-7    | 217                                  | CP-4,OT-4        |
| Cope    | CP-8    | 96                                   | CP-2             |
| Cope    | CP-9    | 216                                  | CP-1, KE-5       |

# Deerhurst

Address: 357 HIGHWAY #8, STONEY CREEK

Year Built: UNKNOWN Facility: OUTDOOR S/S



### Assessment

| <u>Coorre</u> | Equipment Type             | Health Index | Weighting - Outdoor |
|---------------|----------------------------|--------------|---------------------|
| 1)            | Transformer                | 97%          | 30%                 |
| 2)            | Breaker                    | 0%           | 0%                  |
| 3)            | Reclosers                  | 100%         | 15%                 |
| 4)            | Switch Gear                | 0%           | 0%                  |
| 5)            | P&C                        | 0%           | 15%                 |
| 6)            | Station Service            | 60%          | 5%                  |
| 7)            | Site & Civil               | 69%          | 10%                 |
| 8)            | Bus, Switches & Structures | 100%         | 25%                 |
|               | Station Health Index       | 79%          | 100%                |

| Believe y r Bouding |         |                                |                |  |  |
|---------------------|---------|--------------------------------|----------------|--|--|
| Station             | Circuit | Forecasted Peak Current (Amps) | Connected to   |  |  |
| Deerhurst           | DH-1    | 60                             | DH-2,DW-2,DW-3 |  |  |
| Deerhurst           | DH-2    | 26                             | DH-1,DW-1,GA-2 |  |  |
| Deerhurst           | DH-3    | 41                             | DH-1,GA-2      |  |  |

# **Dewitt**

Address: DEWITT ROAD, STONEY CREEK

Year Built: UNKNOWN Facility: OUTDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Outdoor |
|----|----------------------------|--------------|---------------------|
| 1) | Transformer                | 82%          | 30%                 |
| 2) | Breaker                    | 0%           | 0%                  |
| 3) | Reclosers                  | 100%         | 15%                 |
| 4) | Switch Gear                | 0%           | 0%                  |
| 5) | P&C                        | 0%           | 15%                 |
| 6) | Station Service            | 55%          | 5%                  |
| 7) | Site & Civil               | 65%          | 10%                 |
| 8) | Bus, Switches & Structures | 100%         | 25%                 |
|    | Station Health Index       | 74%          | 100%                |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to   |
|---------|---------|--------------------------------------|----------------|
| Dewitt  | DW-1    | 88                                   | DH-2,DW-2,DW-3 |
| Dewitt  | DW-2    | 9                                    | DH-1,DW-1,DW-3 |
| Dewitt  | DW-3    | 19                                   | DH-1,DW-1,DW-2 |

# **Eastmount**

Address: 856 MOHAWK RD. EAST, HAMILTON

Year Built: 1959 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 90%          | 25%                |
| 2) | Breaker                    | 45%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 69%          | 20%                |
| 5) | P&C                        | 45%          | 20%                |
| 6) | Station Service            | 10%          | 5%                 |
| 7) | Site & Civil               | 78%          | 10%                |
| 8) | Bus, Switches & Structures | 0            | 0%                 |
|    | Station Health Index       | 63%          | 100%               |

| Station   | Circuit | Forecasted Peak Current (Amps) | Connected to    |
|-----------|---------|--------------------------------|-----------------|
| Eastmount | EA-1    | 162                            | MK-1,MK-11      |
| Eastmount | EA-2    | 206                            | EA-10,MK-2,WL-3 |
| Eastmount | EA-3    | 239                            | EA-8,MK-10      |
| Eastmount | EA-4    | 113                            | EA-6,EA-11      |
| Eastmount | EA-6    | 156                            | EA-4            |
| Eastmount | EA-7    | 128                            | EA-9            |
| Eastmount | EA-8    | 186                            | EA-3            |
| Eastmount | EA-9    | 165                            | EA-7,MK-6       |
| Eastmount | EA-10   | 132                            | EA-2            |
| Eastmount | EA-11   | 145                            | EA-4            |

## **Elmwood**

Address: 218 WEST 19TH ST., HAMILTON

Year Built: 1958 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 93%          | 25%                |
| 2) | Breaker                    | 73%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 55%          | 20%                |
| 5) | P&C                        | 35%          | 20%                |
| 6) | Station Service            | 15%          | 5%                 |
| 7) | Site & Civil               | 82%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 65%          | 100%               |

| Station | Circuit | Forecasted Peak Current (Amps) | Connected to |
|---------|---------|--------------------------------|--------------|
| Elmwood | EL-2    | 114                            | EL-8,EL-10   |
| Elmwood | EL-3    | 109                            | EL-7,EL-10   |
| Elmwood | EL-4    | 159                            | WL-6,EL-7    |
| Elmwood | EL-5    | 0                              |              |
| Elmwood | EL-7    | 124                            | EL-3,EL-4    |
| Elmwood | EL-8    | 139                            | EL-2,EL-9    |
| Elmwood | EL-9    | 96                             | EL-8,WL-10   |
| Elmwood | EL-10   | 198                            | EL-2, EL-3   |

# Galbraith

Address: 16 GALBRAITH DR., STONEY CREEK

Year Built: 1959

Facility: OUTDOOR S/S



### Assessment

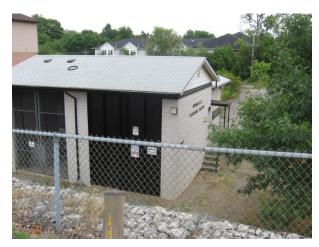
| 100 0001110 | Equipment Type             | Health Index | Weighting - Outdoor |
|-------------|----------------------------|--------------|---------------------|
| 1)          | Transformer                | 95%          | 30%                 |
| 2)          | Breaker                    | 0%           | 0%                  |
| 3)          | Reclosers                  | 100%         | 15%                 |
| 4)          | Switch Gear                | 93%          | 10%                 |
| 5)          | P&C                        | 100%         | 15%                 |
| 6)          | Station Service            | 45%          | 5%                  |
| 7)          | Site & Civil               | 56%          | 10%                 |
| 8)          | Bus, Switches & Structures | 100%         | 15%                 |
|             | Station Health Index       | 91%          | 100%                |

| Station   | Circuit | Forecasted Peak Current (Amps) | Connected to        |
|-----------|---------|--------------------------------|---------------------|
| Galbraith | GA-1    | 29                             | GA-2                |
| Galbraith | GA-2    | 92                             | GA-1,DH-2,DH-3,GA-3 |
| Galbraith | GA-3    | 0                              | GA-2                |

# Highland

Address: 259 GOVERNORS RD., DUNDAS

Year Built: 1977 Facility: INDOOR S/S



### <u>Assessment</u>

| <u> </u> | Equipment Type             | Health Index | Weighting - Indoor |
|----------|----------------------------|--------------|--------------------|
| 1)       | Transformer                | 95%          | 25%                |
| 2)       | Breaker                    | 33%          | 20%                |
| 3)       | Reclosers                  | 0%           | 0%                 |
| 4)       | Switch Gear                | 36%          | 20%                |
| 5)       | P&C                        | 25%          | 20%                |
| 6)       | Station Service            | 50%          | 5%                 |
| 7)       | Site & Civil               | 72%          | 10%                |
| 8)       | Bus, Switches & Structures | 0%           | 0%                 |
|          | Station Health Index       | 52%          | 100%               |

| Station  | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to         |
|----------|---------|--------------------------------------|----------------------|
| Highland | HI-1    | 94                                   | HI-2                 |
| Highland | HI-2    | 119                                  | HI-1,HI-3,JN-1, BD-2 |
| Highland | HI-3    | 126                                  | HI-2                 |

# Hughson

Address: 48 HUGHSON ST. NORTH, HAMILTON

Year Built: 1926 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 95%          | 25%                |
| 2) | Breaker                    | 79%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 81%          | 20%                |
| 5) | P&C                        | 60%          | 20%                |
| 6) | Station Service            | 40%          | 5%                 |
| 7) | Site & Civil               | 55%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 75%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to    |
|---------|---------|--------------------------------------|-----------------|
| Hughson | HU-2    | 13                                   |                 |
| Hughson | HU-4    | 0                                    |                 |
| Hughson | HU-5    | 0                                    |                 |
| Hughson | HU-6    | 277                                  | HU-11,CA-4      |
| Hughson | HU-7    | 0                                    |                 |
| Hughson | HU-8    | 0                                    |                 |
| Hughson | HU-9    | 0                                    |                 |
| Hughson | HU-10   | 0                                    |                 |
| Hughson | HU-11   | 211                                  | HU-6,WT-10,WT-4 |
| Hughson | HU-12   | 0                                    | CA-7            |

# John

Address: 150 HATT ST., DUNDAS

Year Built: 1985 Facility: OUTDOOR S/S



### Assessment

| 1886881116 | Equipment Type             | Health Index | Weighting - Outdoor |
|------------|----------------------------|--------------|---------------------|
| 1)         | Transformer                | 80%          | 30%                 |
| 2)         | Breaker                    | 0%           | 0%                  |
| 3)         | Reclosers                  | 100%         | 15%                 |
| 4)         | Switch Gear                | 0%           | 0%                  |
| 5)         | P&C                        | 67%          | 15%                 |
| 6)         | Station Service            | 50%          | 5%                  |
| 7)         | Site & Civil               | 95%          | 10%                 |
| 8)         | Bus, Switches & Structures | 86%          | 25%                 |
|            | Station Health Index       | 83%          | 100%                |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to   |
|---------|---------|--------------------------------------|----------------|
| John    | JN-1    | 270                                  | HI-2,JN-2,BD-1 |
| John    | JN-2    | 82                                   | JN-1,BD-1      |

## Kenilworth

Address: 96 KENILWORTH AVE. SOUTH, HAMILTON

Year Built: 1960 Facility: INDOOR S/S



### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 91%          | 25%                |
| 2) | Breaker                    | 100%         | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 50%          | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 25%          | 5%                 |
| 7) | Site & Civil               | 61%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 78%          | 100%               |

| Station    | Circuit | Forecasted Peak Current (Amps) | Connected to             |
|------------|---------|--------------------------------|--------------------------|
| Kenilworth | KE-1    | 195                            | KE-3,KE-4,KE-6,OT-3,SP-6 |
| Kenilworth | KE-2    | 128                            | CP-1                     |
| Kenilworth | KE-3    | 176                            | KE-1,KE-5                |
| Kenilworth | KE-4    | 160                            | KE-1,KE-5,KE-6           |
| Kenilworth | KE-5    | 71                             | KE-3,KE-4,BA-2,CP-9      |
| Kenilworth | KE-6    | 142                            | KE-1,KE-4,BA-4           |

# Mohawk

Address: 709 UPPER GAGE, HAMILTON

Year Built: 1953 Facility: INDOOR S/S



### <u>Assessment</u>

| BBIIIC | Equipment Type             | Health Index | Weighting - Indoor |
|--------|----------------------------|--------------|--------------------|
| 1)     | Transformer                | 85%          | 25%                |
| 2)     | Breaker                    | 100%         | 20%                |
| 3)     | Reclosers                  | 0            | 0%                 |
| 4)     | Switch Gear                | 59%          | 20%                |
| 5)     | P&C                        | 90%          | 20%                |
| 6)     | Station Service            | 25%          | 5%                 |
| 7)     | Site & Civil               | 68%          | 10%                |
| 8)     | Bus, Switches & Structures | 0%           | 0%                 |
|        | Station Health Index       | 79%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to        |
|---------|---------|--------------------------------------|---------------------|
| Mohawk  | MK-1    | 192                                  | MK-9,EA-1           |
| Mohawk  | MK-2    | 155                                  | EA-2,MK-5,MK-6,MT-6 |
| Mohawk  | MK-3    | 204                                  | MT-2,MT-3           |
| Mohawk  | MK-5    | 42                                   | MK-2                |
| Mohawk  | MK-6    | 131                                  | MK-2,EA-9           |
| Mohawk  | MK-9    | 180                                  | MK-1,MT-3           |
| Mohawk  | MK-10   | 195                                  | EA-3                |
| Mohawk  | MK-11   | 162                                  | EA-1                |

# Mountain

Address: 510 UPPER WENTWORTH, HAMILTON

Year Built: 1965 Facility: INDOOR S/S



### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 91%          | 25%                |
| 2) | Breaker                    | 100%         | 20%                |
| 3) | Reclosers                  | 0            | 0%                 |
| 4) | Switch Gear                | 57%          | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 25%          | 5%                 |
| 7) | Site & Civil               | 53%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 79%          | 100%               |

| Station  | Circuit | Forecasted Peak<br>Current (Amps) | Connected to            |
|----------|---------|-----------------------------------|-------------------------|
| Mountain | MT-2    | 141                               | MT-3,MK-3               |
| Mountain | MT-3    | 169                               | MT-2,MK-3,MK-9          |
| Mountain | MT-4    | 222                               | MT-5,MT-9,MT-10,MT-11   |
| Mountain | MT-5    | 174                               | MT-4,MT-6,MT-10,WL-9    |
| Mountain | MT-6    | 195                               | MK-2,MT-5,MT-9,WL-2,WL4 |
| Mountain | MT-9    | 205                               | MT-4,MT-6               |
| Mountain | MT-10   | 195                               | CE-10,MT-5,MT-11        |
| Mountain | MT-11   | 0                                 | MT-4,MT-10              |

## Ottawa

Address: 64 DALKEITH ST., HAMILTON

Year Built: 1967 Facility: INDOOR S/S



### Assessment

| <u>sessifie</u> | Equipment Type             | Health Index | Weighting - Indoor |
|-----------------|----------------------------|--------------|--------------------|
| 1)              | Transformer                | 89%          | 25%                |
| 2)              | Breaker                    | 100%         | 20%                |
| 3)              | Reclosers                  | 0%           | 0%                 |
| 4)              | Switch Gear                | 76%          | 20%                |
| 5)              | P&C                        | 90%          | 20%                |
| 6)              | Station Service            | 25%          | 5%                 |
| 7)              | Site & Civil               | 86%          | 10%                |
| 8)              | Bus, Switches & Structures | 0%           | 0%                 |
|                 | Station Health Index       | 85%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to        |
|---------|---------|--------------------------------------|---------------------|
| Ottawa  | OT-1    | 83                                   | OT-2,OT-8           |
| Ottawa  | OT-2    | 157                                  | OT-1,CP-5           |
| Ottawa  | OT-3    | 183                                  | OT-4,KE-1,SP-1,CP-5 |
| Ottawa  | OT-4    | 222                                  | OT-3,CP-7           |
| Ottawa  | OT-5    | 167                                  | CP-5                |
| Ottawa  | OT-6    | 0                                    |                     |
| Ottawa  | OT-7    | 150                                  | SP-7,SP-5           |
| Ottawa  | OT-8    | 113                                  | OT-1                |

# **Parkdale**

Address: 300 PARKDALE AVE. NORTH, HAMILTON

Year Built: 1924 Facility: INDOOR S/S



#### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 100%         | 25%                |
| 2) | Breaker                    | 100%         | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 100%         | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 25%          | 5%                 |
| 7) | Site & Civil               | 66%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 91%          | 100%               |

| Station  | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to       |
|----------|---------|--------------------------------------|--------------------|
| Parkdale | PA-F1   | 178                                  | PA-F5,CP-3,CP-4    |
| Parkdale | PA-F2   | 192                                  | PA-F5              |
| Parkdale | PA-F3   | 171                                  | PA-F6,CP-1,BA-1    |
| Parkdale | PA-F4   | 159                                  | PA-F5, PA-F7       |
| Parkdale | PA-F5   | 159                                  | PA-F1,PA-F2, PA-F4 |
| Parkdale | PA-F6   | 159                                  | PA-F3              |
| Parkdale | PA-F7   | 64                                   | PA-F4              |
| Parkdale | PA-F8   | 0                                    |                    |

# Spadina

Address: 994 KING ST. EAST, HAMILTON

Year Built: 1930 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 88%          | 25%                |
| 2) | Breaker                    | 68%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 79%          | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 20%          | 5%                 |
| 7) | Site & Civil               | 68%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 77%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to   |
|---------|---------|--------------------------------------|----------------|
| Spadina | SP-1    | 154                                  | SP-5,OT-3      |
| Spadina | SP-2    | 204                                  | SP-5,WT-9      |
| Spadina | SP-3    | 194                                  | SP-4,WT-5      |
| Spadina | SP-4    | 132                                  | SP-3,SP-6      |
| Spadina | SP-5    | 222                                  | SP-1,SP-2,OT-7 |
| Spadina | SP-6    | 217                                  | KE-1,SP-4      |
| Spadina | SP-7    | 0                                    | OT-7           |

# Stroud's Lane

Address: 1225 MAIN ST. EAST, HAMILTON

Year Built: 1938 Facility: INDOOR S/S



#### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 85%          | 25%                |
| 2) | Breaker                    | 70%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 37%          | 20%                |
| 5) | P&C                        | 55%          | 20%                |
| 6) | Station Service            | 25%          | 5%                 |
| 7) | Site & Civil               | 71%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 62%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to   |
|---------|---------|--------------------------------------|----------------|
| Strouds | ST-2    | 146                                  | ST-7           |
| Strouds | ST-3    | 267                                  | ST-4           |
| Strouds | ST-4    | 21                                   | ST-3,WH-1,WH-2 |
| Strouds | ST-6    | 171                                  | ST-7,AB-5      |
| Strouds | ST-7    | 182                                  | ST-2,ST-6      |

# Wellington

Address: 227 MOHAWK RD. EAST, HAMILTON

Year Built: 1960 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoo |
|----|----------------------------|--------------|-------------------|
| 1) | Transformer                | 85%          | 25%               |
| 2) | Breaker                    | 100%         | 20%               |
| 3) | Reclosers                  | 0%           | 0%                |
| 4) | Switch Gear                | 59%          | 20%               |
| 5) | P&C                        | 90%          | 20%               |
| 6) | Station Service            | 25%          | 5%                |
| 7) | Site & Civil               | 83%          | 10%               |
| 8) | Bus, Switches & Structures | 0%           | 0%                |
|    | Station Health Index       | 81%          | 100%              |

| Station    | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to         |
|------------|---------|--------------------------------------|----------------------|
| Wellington | WL-1    | 116                                  | WL-8                 |
| Wellington | WL-2    | 193                                  | WL-9, MT-6           |
| Wellington | WL-3    | 116                                  | WL-4                 |
| Wellington | WL-4    | 137                                  | WL-3,MT-6            |
| Wellington | WL-5    | 120                                  | WL-11,WL-8           |
| Wellington | WL-6    | 69                                   | WL-8,WL-9,EL-4       |
| Wellington | WL-8    | 143                                  | WL-1,WL-5,WL-6,WL-10 |
| Wellington | WL-9    | 169                                  | WL-2,WL-6,MT-5       |
| Wellington | WL-10   | 92                                   | WL-8,EL-9            |
| Wellington | WL-11   | 137                                  | WL-5                 |

## Wentworth

Address: 681 KING ST. EAST, HAMILTON

Year Built: 1930 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 90%          | 25%                |
| 2) | Breaker                    | 82%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 73%          | 20%                |
| 5) | P&C                        | 90%          | 20%                |
| 6) | Station Service            | 25%          | 5%                 |
| 7) | Site & Civil               | 64%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 79%          | 100%               |

| Station   | Circuit | Forecasted Peak Current (Amps) | Connected to |
|-----------|---------|--------------------------------|--------------|
| Wentworth | WT-1    | 171                            | WT-6,WT-11   |
| Wentworth | WT-2    | 266                            | WT-11,WT-5   |
| Wentworth | WT-3    | 234                            | WT-4,WT-9    |
| Wentworth | WT-4    | 210                            | WT-3         |
| Wentworth | WT-5    | 256                            | WT-2,SP-3    |
| Wentworth | WT-6    | 152                            | WT-1         |
| Wentworth | WT-8    | 66                             |              |
| Wentworth | WT-9    | 99                             | SP-2,WT-3    |
| Wentworth | WT-10   | 153                            | WT-12        |
| Wentworth | WT-11   | 71                             | WT-1,WT-2    |
| Wentworth | WT-12   | 73                             | WT-10        |

# Whitney

Address: 252 WHITNEY AVE., HAMILTON

Year Built: 1963 Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 92%          | 25%                |
| 2) | Breaker                    | 65%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 43%          | 20%                |
| 5) | P&C                        | 45%          | 20%                |
| 6) | Station Service            | 30%          | 5%                 |
| 7) | Site & Civil               | 83%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 63%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to |
|---------|---------|--------------------------------------|--------------|
| Whitney | WH-1    | 193                                  | ST-4, WH-4   |
| Whitney | WH-2    | 116                                  | WH-6,ST-4    |
| Whitney | WH-3    | 196                                  | WH-5,WH-6    |
| Whitney | WH-4    | 32                                   | WH-1         |
| Whitney | WH-5    | 149                                  | WH-3         |
| Whitney | WH-6    | 91                                   | WH-2,WH-3    |

# York

Address: 230 YORK RD, DUNDAS

Year Built: UNKNOWN Facility: OUTDOOR S/S



#### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Outdoor |
|----|----------------------------|--------------|---------------------|
| 1) | Transformer                | 88%          | 30%                 |
| 2) | Breaker                    | 0%           | 0%                  |
| 3) | Reclosers                  | 100%         | 15%                 |
| 4) | Switch Gear                | 0%           | 0%                  |
| 5) | P&C                        | 90%          | 15%                 |
| 6) | Station Service            | 40%          | 5%                  |
| 7) | Site & Civil               | 73%          | 10%                 |
| 8) | Bus, Switches & Structures | 83%          | 25%                 |
|    | Station Health Index       | 85%          | 100%                |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to |
|---------|---------|--------------------------------------|--------------|
| York    | YK-1    | 75                                   | YK-2         |
| York    | YK-2    | 39                                   | YK-1         |

## Grantham

Address: 319  $\frac{1}{2}$  GRANTHAM AVE.,

ST.CATHARINES

Year Built: 1965 Facility: INDOOR S/S



#### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 82%          | 25%                |
| 2) | Breaker                    | 52%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 57%          | 20%                |
| 5) | P&C                        | 35%          | 20%                |
| 6) | Station Service            | 63%          | 5%                 |
| 7) | Site & Civil               | 59%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 58%          | 100%               |

| Dependence | y / Loudi | <del>115</del>                       |              |  |  |  |  |  |  |
|------------|-----------|--------------------------------------|--------------|--|--|--|--|--|--|
| Station    | Circuit   | Forecasted<br>Peak Current<br>(Amps) | Connected to |  |  |  |  |  |  |
| Grantham   | GRF1      | 216                                  | VIF3,GRF2    |  |  |  |  |  |  |
| Grantham   | GRF2      | 169                                  | GRF1,GRF4    |  |  |  |  |  |  |
| Grantham   | GRF3      | B.E.                                 |              |  |  |  |  |  |  |
| Grantham   | GRF4      | 105                                  | GRF2         |  |  |  |  |  |  |

## **Vine**

Address: 95 VINE ST.,

ST.CATHARINES

Year Built: 1959 Facility: INDOOR S/S



### <u>Assessment</u>

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 70%          | 25%                |
| 2) | Breaker                    | 52%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 61%          | 20%                |
| 5) | P&C                        | 50%          | 20%                |
| 6) | Station Service            | 38%          | 5%                 |
| 7) | Site & Civil               | 53%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 57%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to    |  |  |  |  |  |
|---------|---------|--------------------------------------|-----------------|--|--|--|--|--|
| Vine    | VIF1    | 137                                  | VIF5            |  |  |  |  |  |
| Vine    | VIF3    | 147                                  | GRF1            |  |  |  |  |  |
| Vine    | VIF4    | 176                                  | VIF5,WEF1       |  |  |  |  |  |
| Vine    | VIF5    | 201                                  | VIF1,VIF4, WEF4 |  |  |  |  |  |

### Welland

Address: 136 WELLAND AVE.,

ST.CATHARINES

Year Built:

Facility: INDOOR S/S



### Assessment

|    | Equipment Type             | Health Index | Weighting - Indoor |
|----|----------------------------|--------------|--------------------|
| 1) | Transformer                | 85%          | 25%                |
| 2) | Breaker                    | 60%          | 20%                |
| 3) | Reclosers                  | 0%           | 0%                 |
| 4) | Switch Gear                | 55%          | 20%                |
| 5) | P&C                        | 40%          | 20%                |
| 6) | Station Service            | 38%          | 5%                 |
| 7) | Site & Civil               | 45%          | 10%                |
| 8) | Bus, Switches & Structures | 0%           | 0%                 |
|    | Station Health Index       | 59%          | 100%               |

| Station | Circuit | Forecasted<br>Peak Current<br>(Amps) | Connected to |
|---------|---------|--------------------------------------|--------------|
| Welland | WEF1    | 101                                  | WEF2,VIF4    |
| Welland | WEF2    | 0                                    | WEF1         |
| Welland | WEF4    | 70                                   | VIF5         |

### 7. Recommendations:

- 1. Horizon Utilities should continue to follow the voltage conversion outline provided in this document for 4.16 kV and 8.32 kV Asset Renewal.
- 2. The organization should maintain a 40 year project plan for 4.16 kV and 8.32 kV asset renewal and determine an appropriate level of investment and rate of progress for the Renewal Program.
- 3. The organization should continue to include in its capital plans a program of investment in substation assets that will ensure the reliable performance of the stations until their anticipated decommissioning dates.
- 4. Adequate maintenance programs should continue in these areas throughout the life of the Renewal Program.
- 5. The organization should complete a regular review of the assessments to determine if the plan or priorities require to be altered.
- 6. The organization should integrate smart grid strategies with the Renewal Program when rebuilding distribution system to capture synergies.
- 7. Included in the appendix is the revised 40 year renewal schedule for all 4.16 kV and 8.32 kV assets.

# **Appendix**

**Horizon Renewal Schedule 2009-2049** 

Distribution System Conversion Plan

Horizon Utilities Corporation

|               | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Aberdeen      |      |      |      |      |      | 1/6  |      |      |      |      |      | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |
| Bartonville   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/4  |      |      |      |      |      |      |      |
| Baldwin       |      |      |      |      |      |      |      |      |      |      |      |      | 1/2  | 2/2  |      |      |      |      |      |      |      |      |      |
| Caroline      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  | 7/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Central       |      |      |      |      |      |      |      |      |      |      | 1/7  | 2/7  | 3/7  | 4/7  | 5/7  | 6/7  | 7/7  |      |      |      |      |      |      |
| Cope          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Deerhurst     |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/3  | 2/3  | 3/3  |      |      |      |      |      |      |
| Dewitt        |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/4  | 2/4  | 3/4  | 4/4  |      |      |      |      |      |
| Eastmount     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  |
| Elmwood       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  |
| Galbraith     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/4  | 2/4  | 3/4  | 4/4  |      |      |      |      |
| Grantham      |      |      |      |      |      |      |      |      |      | 1/3  | 2/3  | 3/3  |      |      |      |      |      |      |      |      |      |      |      |
| Halson        | 1/4  | 2/4  | 3/4  | 4/4  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Highland      |      |      |      |      |      |      |      |      | 1/3  | 2/3  | 3/3  |      |      |      |      |      |      |      |      |      |      |      |      |
| Hughson       |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  | 7/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| John          |      |      |      |      |      |      |      |      |      |      |      |      | 1/2  | 2/2  |      |      |      |      |      |      |      |      |      |
| Kenilworth    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Mohawk        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Mountain      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Ottawa        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Parkdale      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Spadina       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Stroud's Lane |      |      |      |      |      |      |      |      | 1/5  | 2/5  | 3/5  | 4/5  | 5/5  |      |      |      |      |      |      |      |      |      |      |
| Taylor        |      |      |      | 1/3  | 2/3  | 3/3  | 4/3  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Vine          |      |      |      |      |      |      |      |      |      | 1/3  | 2/3  | 3/3  |      |      |      |      |      |      |      |      |      |      |      |
| Webster       |      |      | 1/3  | 2/3  | 3/3  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Welland       |      |      |      |      |      | 1/3  |      | 2/3  | 3/3  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Wellington    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Wentworth     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Whitney       |      |      |      |      |      |      |      |      | 1/5  | 2/5  | 3/5  | 4/5  | 5/5  |      |      |      |      |      |      |      |      |      |      |
| York          |      |      |      |      |      |      |      |      |      |      |      |      | 1/2  | 2/2  |      |      |      |      |      |      |      |      |      |

Substation Renewal Plan Schedule 2006 - 2028

Engineering & Asset Management

Distribution System Conversion Plan

Horizon Utilities Corporation

|               | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Aberdeen      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Bartonville   |      |      |      |      |      |      |      | 2/4  | 3/4  | 4/4  |      |      |      |      |      |      |      |      |      |      |      |
| Baldwin       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Caroline      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Central       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Cope          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |
| Deerhurst     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Dewitt        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Eastmount     | 6/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Elmwood       | 6/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Galbraith     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Grantham      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Halson        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Highland      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Hughson       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| John          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Kenilworth    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |
| Mohawk        |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Mountain      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Ottawa        |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |
| Parkdale      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |
| Spadina       |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |      |
| Stroud's Lane |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Taylor        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Vine          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Webster       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Welland       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Wellington    |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Wentworth     |      |      |      |      |      |      |      | 1/6  | 2/6  | 3/6  | 4/6  | 5/6  | 6/6  |      |      |      |      |      |      |      |      |
| Whitney       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| York          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

Substation Renewal Plan Schedule 2029 - 2049

Engineering & Asset Management