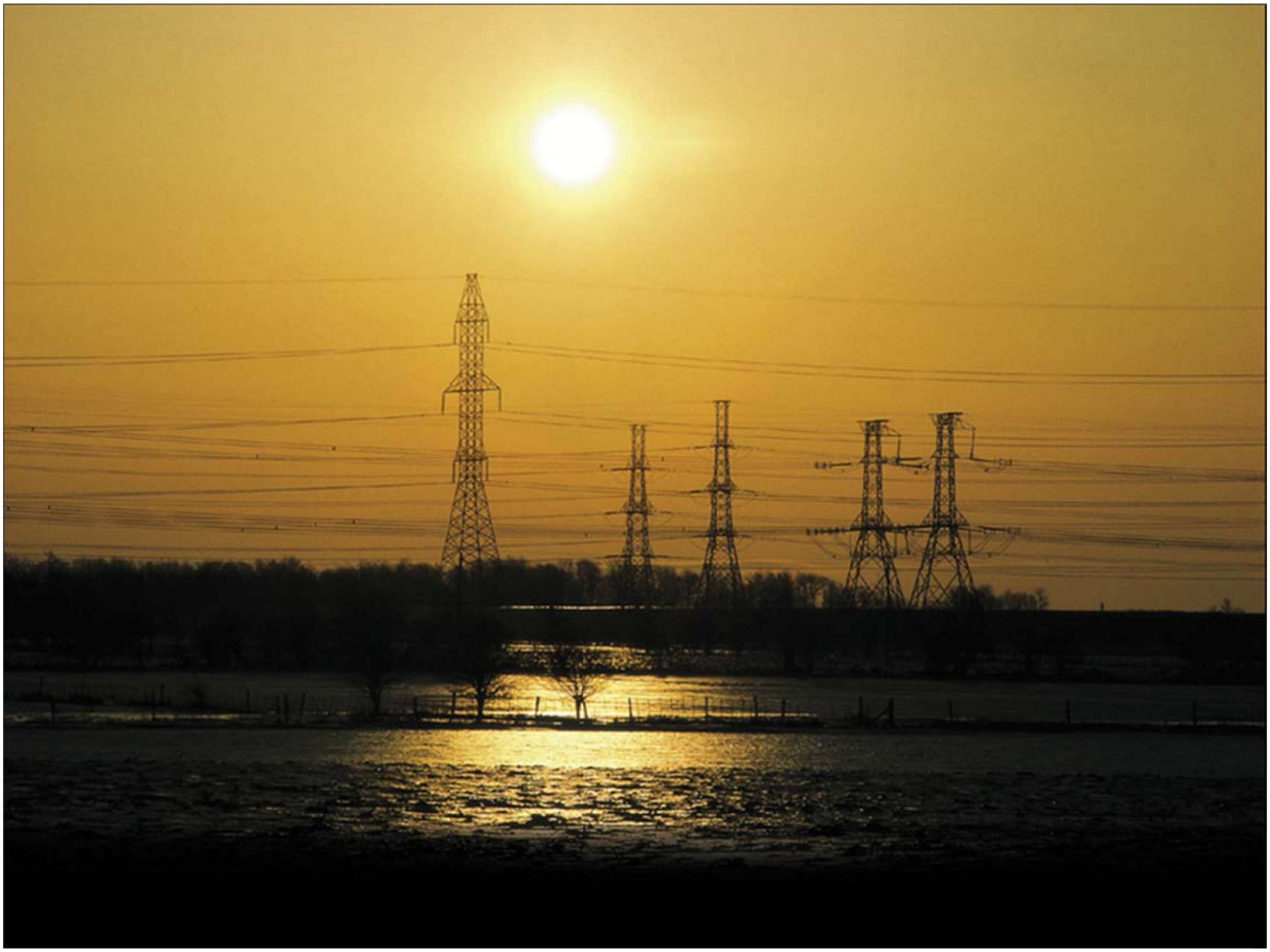

Burlington to Nanticoke

REGIONAL INFRASTRUCTURE PLAN

October 08, 2019

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Prepared and supported by:

Company
Brantford Power Inc.
Burlington Hydro Inc.
Energy + Inc.
Alectra Utilities Corporation (former Horizon Utilities Inc.)
Hydro One Networks Inc. (Distribution)
Independent Electricity System Operator (IESO)
Oakville Hydro
Hydro One Networks Inc. (Lead Transmitter)

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Disclaimer

This Regional Infrastructure Plan ("RIP") report was prepared for the purpose of developing an electricity infrastructure plan to address all near and mid-term needs (2019-2029) identified in previous planning phases and any additional needs identified based on new and/or updated information provided by the RIP Study Team.

The preferred solution(s) that have been identified in this report may be reevaluated based on the findings of further analysis. The load forecast and results reported in this RIP report are based on the information provided and assumptions made by the participants of the RIP Study Team.

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EXECUTIVE SUMMARY

THIS REGIONAL INFRASTRUCTURE PLAN ("RIP") WAS PREPARED BY HYDRO ONE WITH PARTICIPATION AND INPUT FROM THE RIP STUDY TEAM IN ACCORDANCE WITH THE ONTARIO TRANSMISSION SYSTEM CODE REQUIREMENTS. IT IDENTIFIES INVESTMENTS IN TRANSMISSION FACILITIES, DISTRIBUTION FACILITIES, OR BOTH, THAT SHOULD BE PLANNED, DEVELOPED AND IMPLEMENTED TO MEET THE ELECTRICITY INFRASTRUCTURE NEEDS WITHIN THE BURLINGTON TO NANTICOKE REGION.

The participants of the Regional Infrastructure Plan ("RIP") Study Team included members from the following organizations:

- Alectra Utilities Corporation (former Horizon Utilities Inc.)
- Brantford Power Inc.
- Burlington Hydro Inc.
- Energy + Inc.
- Hydro One Networks Inc. (Distribution)
- Hydro One Networks Inc. (Lead Transmitter)
- Independent Electricity System Operator (IESO)
- Oakville Hydro

The first regional planning cycle for the Burlington to Nanticoke Region was completed in February 2017 with the publication of the RIP report. Due to several sustainment needs arising during the final phase of the 1st cycle regional planning, the Study Team and the RIP recommended to trigger 2nd regional planning cycle.

This RIP is the final phase of the 2nd regional planning cycle and follows the completion of the Integrated Regional Resource Plans ("IRRP") for Hamilton sub-region in February 2019 and the 2nd Cycle Burlington to Nanticoke Region's Needs Assessment ("NA") in May 2017. This RIP provides a consolidated summary of the needs and recommended plans for the Burlington to Nanticoke Region in the near-term (up to 5 years) and the mid-term (5 to 10 years).

It should be noted that this RIP, in addition to advancing the work from the aforementioned IRRP, also identifies additional needs related to load growth and end-of-life facilities in the Burlington to Nanticoke Region.

This RIP discusses needs identified in the previous regional planning cycle, the Needs Assessment report for this cycle and the Hamilton Sub-region IRRP; and the projects developed to address these needs. Implementation plans to address some of these needs are already completed or are underway. Since the previous regional planning cycle, following projects have been completed:

1- Bronte TS: 115 kV B7/B8 Transmission line capacity
2- Beach TS: Replace EOL T3/T4 transformers
3- Horning TS: Refurbish EOL transformers T1/T2 & switchgears
4- Mohawk TS: Replace EOL T1/T2 transformers
5- Brant Switching Station: 115 kV B12BL/ B13BL Transmission line capacity
6- Bronte TS (T5/T6 DESN): Refurbish EOL transformers T5/T6 & switchgears
7- Cumberland TS: Power Factor Correction

The major infrastructure investments recommended by the Study Team in the near and mid -term planning horizon are provided below in Table 1 and 2 respectively, along with their planned in-service date and budgetary estimates for planning purpose.

Table 1: Near-Term Needs in Burlington to Nanticoke Region

No.	Need	Recommended Action Plan	Planned I/S Date	Budgetary Estimate ($M)
1	115 kV B7/B8: EOL line section from Burlington TS to Nelson Jct.	Refurbish the EOL B7/B8 line section	2020	2
2	115 kV B3/B4: EOL line section from Horning Mountain Jct. to Glanford Jct.	Refurbish the EOL B3/B4 line section conductor	2020	22
3	Elgin TS: EOL transformers & switchgears	Replace transformers and reduce 2 DESNs to 1 DESN	2021	81
4	Newton TS: EOL transformers	Replace EOL transformers	2021	22
5	Kenilworth TS: EOL transformer & switchgear	Reconfigure from 2 DESNs to single DESN and replace EOL equipment	2021	36
6	Dundas TS: Load transfer	Add two new feeders at Dundas TS #2	2021	2
7	Gage TS: EOL transformers & switchgear	Reduce from 3 DESNs to 2 DESNs and replace EOL equipment	2021	55
8	Kenilworth TS: Power factor correction	LDC is developing distribution option	2022	1
9	Norfolk area supply capacity	Norfolk TS: Install capacitor bank	2022	3

Table 2: Mid- and Long-Term Needs in Burlington to Nanticoke Region

No.	Needs	Recommended Plan of action	Planned I/S Date	Budgetary Estimate ($M)
1	Birmingham TS: EOL transformer and metalclad switchgears	Replace EOL equipment	2025	29
2	Mid-Term EOL transformers at Nebo TS (T3/T4), Caledonia TS (T1) and Jarvis TS (T3/T4)	Monitor and review in next planning cycle	2025-29	69
3	Mid-Term EOL switchgear at Norfolk TS and Burlington TS[1]	Monitor and review in next planning cycle	2026	57
4	EOL cables in Hamilton sub-region: H5K/H6K, K1G/K2G, HL3/HL4[2]	To further assess the options in this RIP by the Study Team and addendum issued to Hamilton IRRP and RIP	2026	28
5	Norfolk area supply capacity	To further assess the options in this RIP by the Study Team in advance of next planning cycle and addendum issued to RIP	2026	80
6	Beach TS: EOL 230 kV auto-transformers[3] and DESN transformers	To be assessed as part of Middleport Bulk Study by the IESO in coordination with Hydro One	2027	71
7	Lake TS: EOL transformers and switchgears	Monitor and review in next planning cycle	2027	45
8	Burlington TS: EOL 230 kV auto-transformer [3]	To be assessed as part of Middleport Bulk Study by the IESO in coordination with Hydro One	2030	14

[1] Further condition assessment did not confirm the earlier need of refurbishing Brantford switchgear
[2] To be finalized after the completion of Hamilton IRRP Addendum by the IESO
[3] To be finalized after the completion of Middleport Bulk Study by the IESO

The Study Team recommends that:

- Hydro One to continue with the implementation of major infrastructure investments listed in Table 1 while keeping the Study Team apprised of project status;
- Hydro One to continue with the implementation of infrastructure investment at Birmingham TS for replacement of EOL transformers and switchgears;
- The EOL 230 kV autotransformer options at Beach TS and Burlington TS will be assessed through the IESO Middleport Bulk Study in coordination with Hydro One to develop a final recommended plan;
- The EOL 115 kV Hamilton area cables options are included in this RIP. It will be further assessed by the Study Team to develop a recommended plan to be included as an addendum to the Hamilton IRRP and this RIP;
- The options to reinforce supply to the Norfolk area are included in this RIP and will be further assessed by the Study Team in advance of the next planning cycle to develop a recommended plan and an addendum be made to the RIP; and
- All the other identified needs/options in the mid and long-term will be further reviewed by the Study Team in the next regional planning cycle.

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1. INTRODUCTION

THIS REPORT PRESENTS THE REGIONAL INFRASTRUCTURE PLAN ("RIP") TO ADDRESS THE ELECTRICITY NEEDS OF THE BURLINGTON TO NANTICOKE REGION.

The report was prepared by Hydro One Networks Inc. ("Hydro One") and documents the results of the joint study carried out by Burlington o Nanticoke RIP Study Team. . In addition to Hydro One representatives, other members of the RIP Study Team included representative from Brantford Power Inc. ("Brantford Power"), Burlington Hydro Inc. ("Burlington Hydro"), Energy + Inc. ("Energy +"), Alectra Utilities Corporation (former Horizon Utilities Inc. "Alectra Utilities"), Hydro One Distribution, the Independent Electricity System Operator ("IESO") and Oakville Hydro Electricity Distribution Inc. ("Oakville Hydro") in accordance with the Regional Planning process established by the Ontario Energy Board ("OEB") in 2013.

The Burlington to Nanticoke region covers the City of Brantford, Municipality of Hamilton, counties of Brant, Haldimand and Norfolk. The portions of Cities of Burlington and Oakville south of Dundas street are included in the Burlington to Nanticoke region up to Third Line road in the east. Electrical supply to the region is provided from twenty-nine 230 kV and 115 kV step-down transformer stations. The sum of 2018 non-coincident summer station peak load of the Region was about 2381 MW. The boundaries of the Region are shown in Figure 1-1 below.

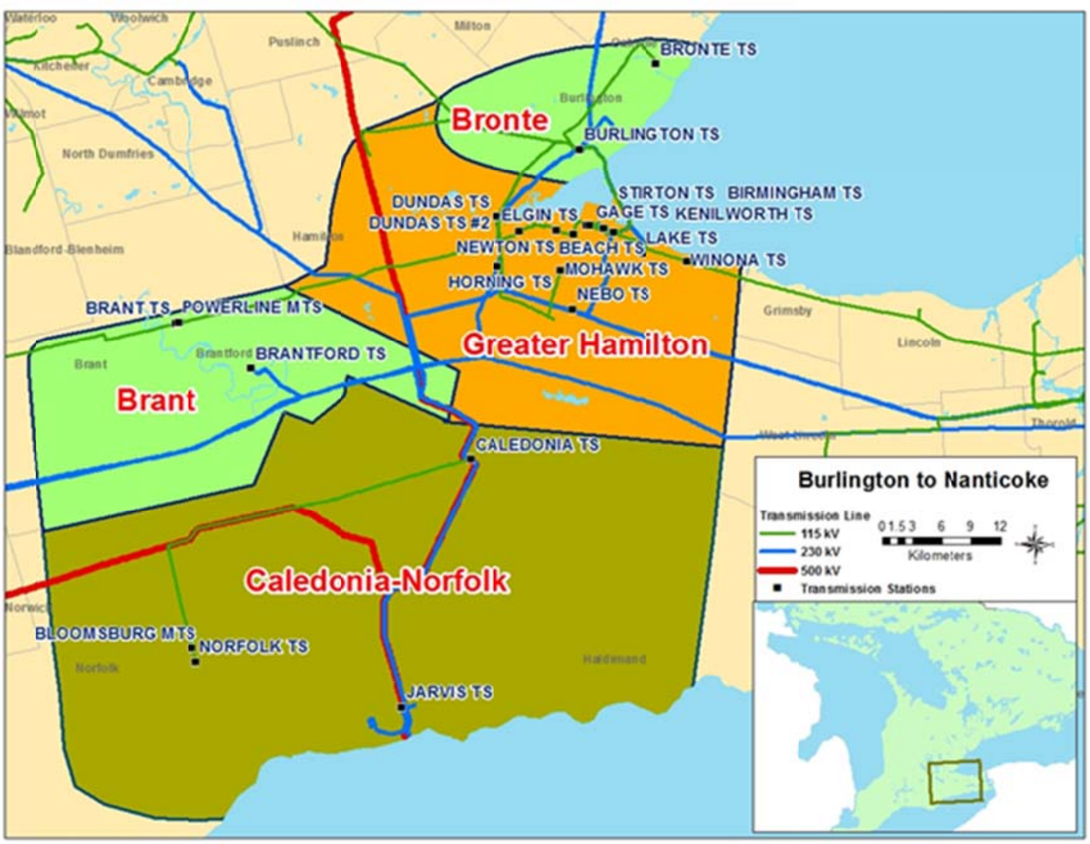

Figure 1-1 Burlington to Nanticoke Region

1.1 Objective and Scope

The RIP report examines the needs in the Burlington to Nanticoke Region. Its objectives are to:

- Provide a comprehensive summary of needs and wires plans to address the needs;
- Identify any new needs that may have emerged since previous planning phases e.g., Needs Assessment ("NA") and/or Integrated Regional Resource Plan("IRRP");
- Assess and develop a wires plan to address these new needs; and
- Identify investments in transmission and distribution facilities or both that should be developed and implemented on a coordinated basis to meet the electricity infrastructure needs within the region.

The RIP reviewed factors such as the load forecast, major high voltage sustainment issues emerging over the near, mid- and long-term horizon, transmission and distribution system capability along with any updates to local plans, conservation and demand management ("CDM") forecasts, renewable and non-renewable generation development, and other electricity system and local drivers that may impact the need and alternatives under consideration.

The scope of this RIP is as follows:

- A consolidated summary of the wires plan developed during LP (Local Planning), SA (Scoping Assessment), and/or as identified in IRRP phase.
- Discussion of any other major transmission infrastructure investment plans over the near to mid-term planning horizon(0-10 years)
- Identification of any new needs and a wires plan to address these needs based on new and/or updated information.

1.2 Structure

The rest of the report is organized as follows:

- Section 2 provides an overview of the regional planning process.
- Section 3 describes the regional characteristics.
- Section 4 describes the transmission work completed over the last ten years.
- Section 5 describes the load forecast and study assumptions used in this assessment.
- Section 6 describes the results of the adequacy assessment of the transmission facilities and identifies needs.
- Section 7 discusses the needs and provides the alternatives and preferred solutions.
- Section 8 provides the conclusion and next steps.

2. REGIONAL PLANNING PROCESS

2.1 Overview

Planning for the electricity system in Ontario is done at three levels: bulk system planning, regional system planning, and distribution system planning. These levels differ in the facilities that are considered and the scope of impact on the electricity system. Planning at the bulk system level typically looks at issues that impact the system on a provincial level, while planning at the regional and distribution levels looks at issues on a more regional or localized level.

Regional planning looks at supply and reliability issues at a regional or local area level. Therefore, it largely considers the 115 kV and 230 kV portions of the power system that supply various parts of the province.

2.2 Regional Planning Process

A structured regional planning process was established by the Ontario Energy Board ("OEB") in 2013 through amendments to the Transmission System Code ("TSC") and Distribution System Code ("DSC"). The process consists of four phases: the Needs Assessment[4] ("NA"), the Scoping Assessment ("SA"), the Integrated Regional Resource Plan ("IRRP"), and the Regional Infrastructure Plan ("RIP").

The regional planning process begins with the NA phase, which is led by the transmitter to determine if there are regional needs. The NA phase identifies the needs and the Study Team determines whether further regional coordination is necessary to address them. If no further regional coordination is required, further planning is undertaken by the transmitter and the impacted local distribution company ("LDC") or customer and develops a Local Plan ("LP") to address them.

In situations where identified needs require coordination at the regional or sub-regional levels, the IESO initiates the SA phase. During this phase, the IESO, in collaboration with the transmitter and impacted LDCs, reviews the information collected as part of the NA phase, along with additional information on potential non-wires alternatives, and makes a decision on the most appropriate regional planning approach. The approach is either a RIP, which is led by the transmitter, or an IRRP, which is led by the IESO. If more than one sub-region was identified in the NA phase, it is possible that a different approach could be taken for different sub-regions.

The IRRP phase will generally assess infrastructure (wires) versus resource (CDM and Distributed Generation) options at a higher or more macro level, but sufficient to permit a comparison of options. If the IRRP phase identifies that infrastructure options may be most appropriate to meet a need, the RIP phase will conduct detailed planning to identify and assess the specific wires alternatives and recommend a preferred wires solution. Similarly, resource options that the IRRP identifies as best suited to meet a

[4] Also referred to as Needs Screening

need are then further planned in greater detail by the IESO. The IRRP phase also includes IESO led stakeholder engagement with municipalities, Indigenous communities, business sectors and other interested stakeholders in the region. The Hamilton IRRP was identified in the Scoping Assessment phase of the Burlington to Nanticoke Region's second regional planning cycle and was completed in February 2019.

The RIP phase is the fourth and final phase of the regional planning process and involves: discussion of previously identified needs and plans; identification of any new needs that may have emerged since the start of the planning cycle; and development of a wires plan to address the needs where a wires solution would be the best overall approach. This phase is led and coordinated by the transmitter and the deliverable is a comprehensive report of a wires plan for the region. Once completed, this report is also referenced in transmitter's rate filing submissions and as part of LDC rate applications with a planning status letter provided by the transmitter.

To efficiently manage the regional planning process, Hydro One has been undertaking wires planning activities in collaboration with the IESO and/or LDCs for the region as part of and/or in parallel with:

- Planning activities that were already underway in the region prior to the new regional planning process taking effect.
- The NA, SA, and LP phases of regional planning.
- Participating in and conducting wires planning as part of the IRRP for the region or sub-region.
- Working and planning for connection capacity requirements with the LDCs and transmission connected customers.

Figure 2-1 illustrates the various phases of the regional planning process (NA, SA, IRRP, and RIP) and their respective phase trigger, lead, and outcome.

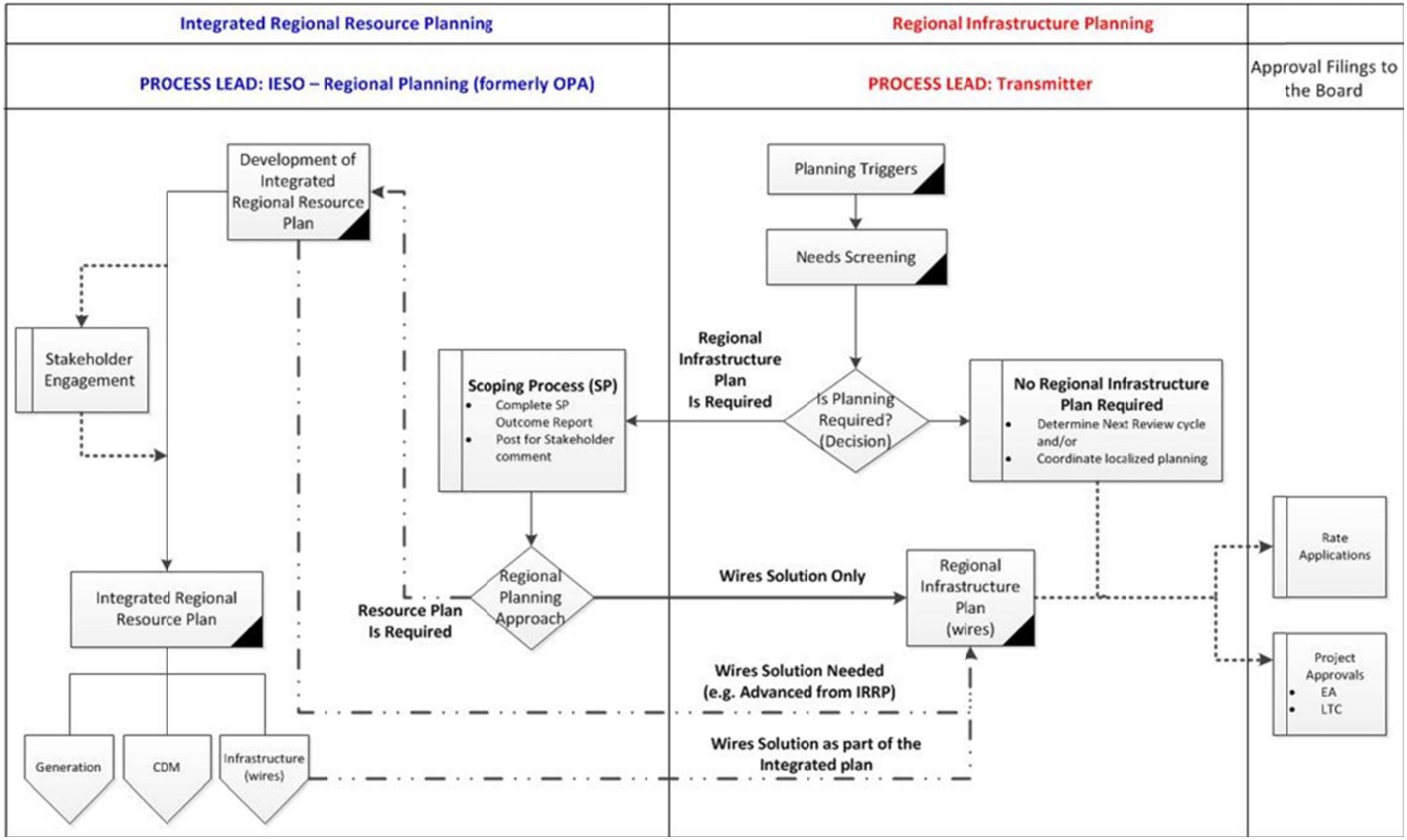

Figure 2-1 Regional Planning Process Flowchart

2.3 RIP Methodology

The RIP phase consists of a four step process (see Figure 2-2) as follows:

1. Data Gathering: The first step of the process is the review of planning assessment data collected in the previous phase of the regional planning process. Hydro One collects this information and reviews it with the Study Team to reconfirm or update the information as required. The data collected includes:
   - Net peak demand forecast at the transformer station level. This includes the effect of any distributed generation or conservation and demand management programs.
   - Existing area network and capabilities including any bulk system power flow assumptions.
   - Other data and assumptions as applicable such as asset conditions; load transfer capabilities, and previously committed transmission and distribution system plans.
2. Technical Assessment: The second step is a technical assessment to review the adequacy of the regional system including any previously identified needs. Depending upon the changes to load forecast or other relevant information, regional technical assessment may or may not be required or be limited to specific issue only. Additional near and mid-term needs may be identified in this phase.
3. Alternative Development: The third step is the development of wires options to address the needs and to come up with a preferred alternative based on an assessment of technical considerations, feasibility, environmental impact and costs.
4. Implementation Plan: The fourth and last step is the development of the implementation plan for the preferred alternative.

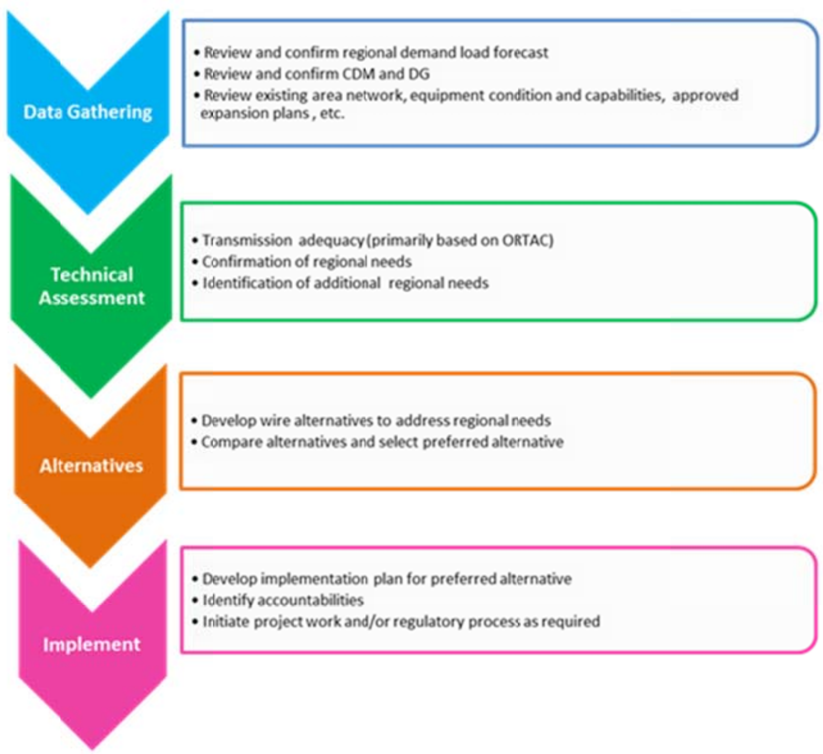

Figure 2-2 RIP Methodology

3. REGIONAL CHARACTERISTICS

THE BURLINGTON TO NANTICOKE REGION COVERS THE CITY OF BRANTFORD, MUNICIPALITY OF HAMILTON, COUNTIES OF BRANT, HALDIMAND AND NORFOLK. SOME OF THE ELECTRICAL INFRASTRUCTURE IN THE REGION IS ONE OF THE OLDEST INSTALLATIONS IN THE PROVINCE. THE PORTIONS OF CITIES OF BURLINGTON AND OAKVILLE SOUTH OF DUNDAS STREET ARE INCLUDED IN THE BURLINGTON TO NANTICOKE REGION UP TO THIRD LINE ROAD IN THE EAST.

Bulk electrical supply to the Burlington to Nanticoke Region is provided through the 500/230 kV autotransformers at Nanticoke TS and Middleport TS and 230 kV circuits from Middleport TS, Nanticoke TS and Beck TS. The 115 kV network is supplied by 230/115 kV autotransformers at Burlington TS, Beach TS and Caledonia TS. The area loads are supplied by a network of 230 kV and 115 kV transmission lines and step-down transformation facilities. The area has been divided into four sub-regions as shown in Figure 1-1 and described below:

- The Brant sub-region encompasses the County of Brant, City of Brantford and surrounding areas. Electricity supply to the sub-region is provided by:
  - Brant TS and Powerline MTS supplied by 115 kV double circuit B12BL/B13BL line and B2 single circuit line.
  - Brantford TS supplied by the 230 kV double circuit transmission line M32W/M33W.

The Brant Sub-region transmission facilities are shown in Figure 3-1.

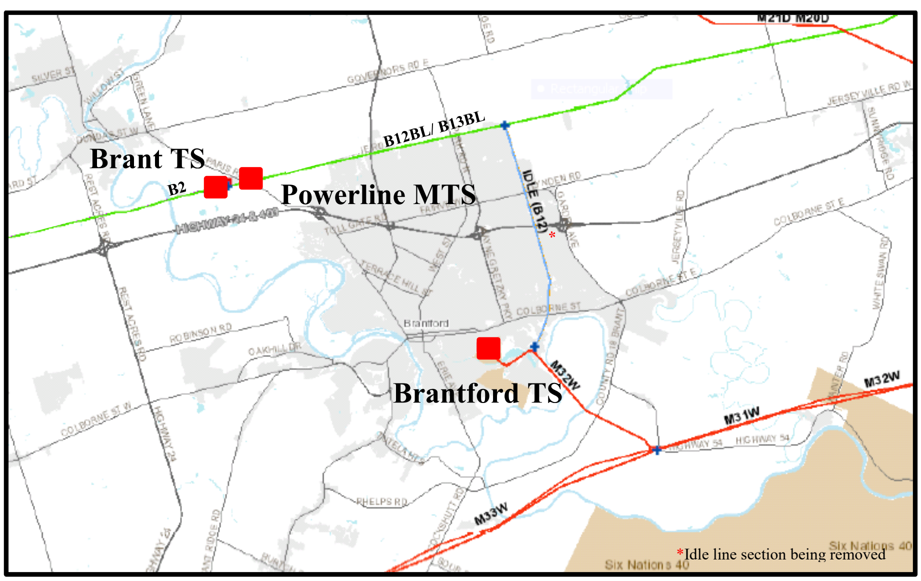

Figure 3-1 Brant sub-region

The total 2018 non-coincident peak demand of the three stations was 289 MW. Energy + Inc. and Brantford Power Inc. are the main LDCs that serve the electricity demand for the City of Brantford. Hydro One Distribution supplies load in the outlying areas of the sub-region. The electricity demand is comprised of residential, commercial and industrial customers.

- The Bronte sub-region covers the City of Burlington and the western part of the City of Oakville up to Third Line. Electricity supply to the sub-region is provided by:
  - Bronte TS supplied by 115 kV double circuit line B7/B8.
  - Burlington TS supplied by 230 kV double circuit line Q23BM/ Q25BM.
  - Cumberland TS supplied from 230 kV double circuit transmission line B40C/B41C.

  The Bronte sub-region transmission facilities are shown in Figure 3-2.

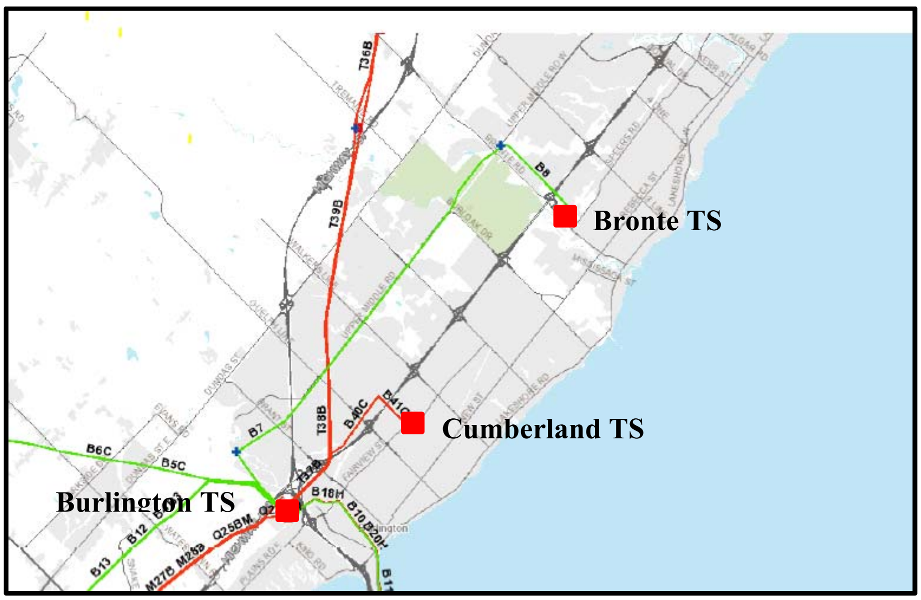

Figure 3-2 Bronte sub-region

The area is served by Burlington Hydro and Oakville Hydro. The electricity demand is comprised of residential, commercial and industrial customers. The total 2018 non-coincident peak station demand of the three stations was 401 MW.

- The Greater Hamilton sub-region encompasses the City of Hamilton that includes Townships of Flamborough and Glanbrook and towns of Dundas and Stoney Creek. Some of the electrical infrastructure in the sub-region was built over 50 years ago and is one of the oldest installations in the province. Electricity supply to the sub-region is grouped as follows:
  - Beach TS 115 kV area which includes four 115 kV step down stations Birmingham TS, Kenilworth TS, Stirton TS and Winona TS supplied from the 230/115 kV autotransformers at Beach TS.

- Burlington TS 115 kV area which includes Dundas TS, Dundas #2, Elgin TS, Gage TS, Mohawk TS, Newton TS and one customer owned CTS supplied from the 230/115 kV autotransformers at Burlington TS.

- 230 kV area which includes Beach TS (T3/T4 & T5/T6 DESNs), Horning TS, Nebo TS, Lake TS and two customer owned stations supplied from 230 kV circuits connecting into Beach TS and Burlington TS.

The Greater Hamilton sub-region transmission facilities are shown in Figure 3-3.

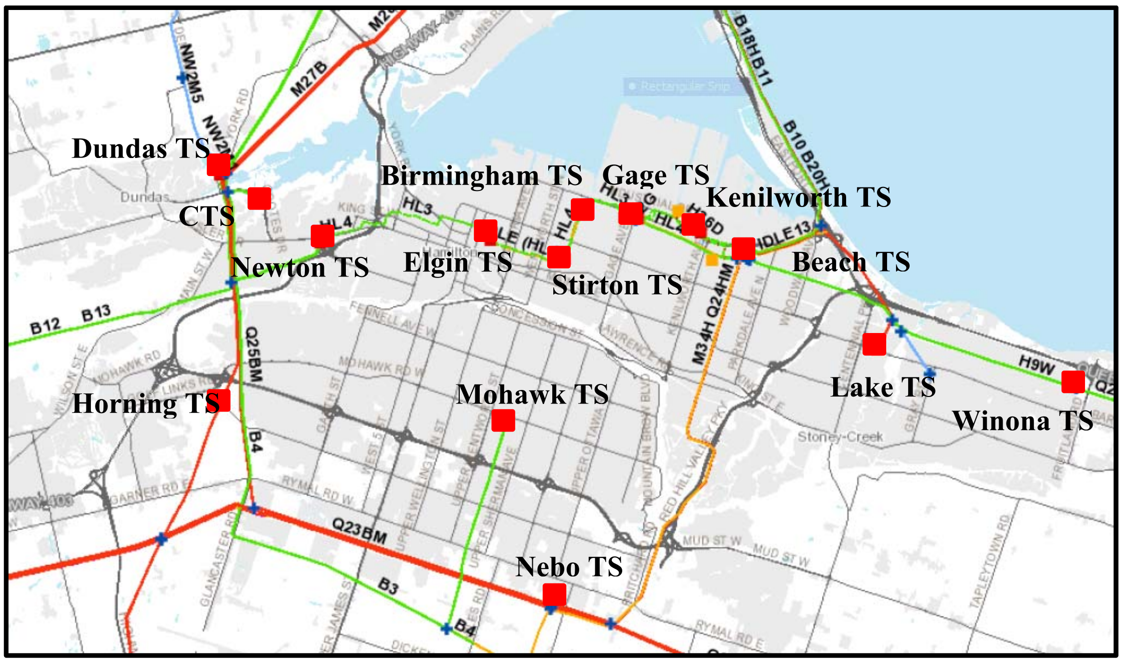

Figure 3-3 Greater Hamilton sub-region

The total 2018 non-coincident peak demand of the Greater Hamilton sub-region was 1371 MW. The area is served by Alectra Utilities, Hydro One Distribution and CTSs comprises a significant number of large industrial customers along with commercial and residential customers.

- The Caledonia Norfolk sub-region covers the eastern part of Norfolk County and the western part of Haldimand County. Electricity supply to the Sub-region is provided by:

- Caledonia TS supplied by 230 kV double circuit line N5M/S39M.
- Jarvis TS and a CTS supplied from the 230 kV double circuit line N21J/N22J.
- One CTS supplied from the 230 kV single circuit N20K.
- Bloomsburg DS and Norfolk TS supplied from 115 kV double circuit transmission line C9/C12.

The Caledonia Norfolk sub-region transmission facilities are shown in Figure 3-4.

The area is served by Hydro One Distribution. The electricity demand mix is comprised of residential, commercial and industrial uses. The 2018 non-coincident peak demand of this sub-region was 320 MW.

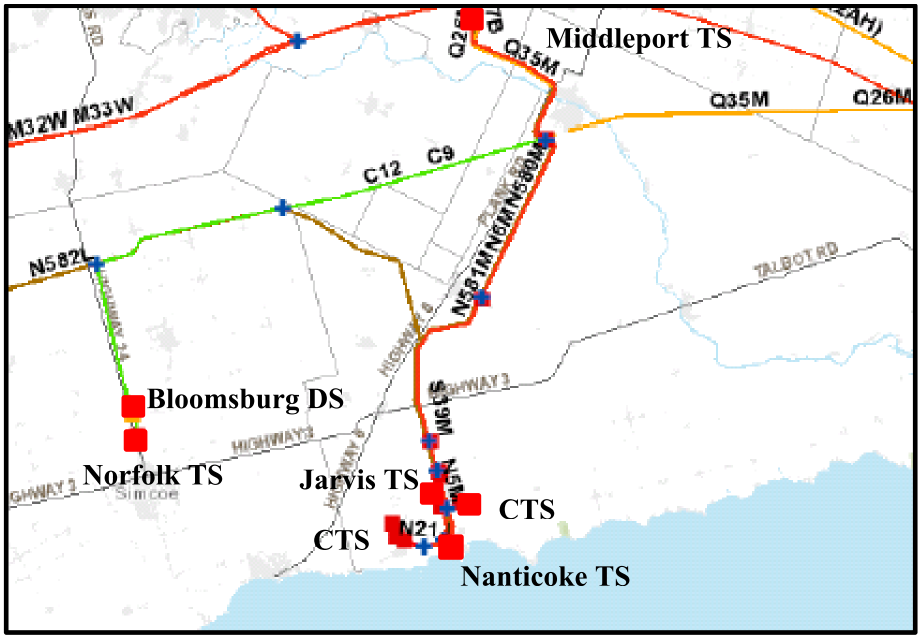

Figure 3-4 Caledonia Norfolk sub-region

Electrical single line diagrams for the Burlington to Nanticoke region's 500 kV/ 230 kV facilities and 115 kV facilities are shown below in Figure 3-5 and Figure 3-6.

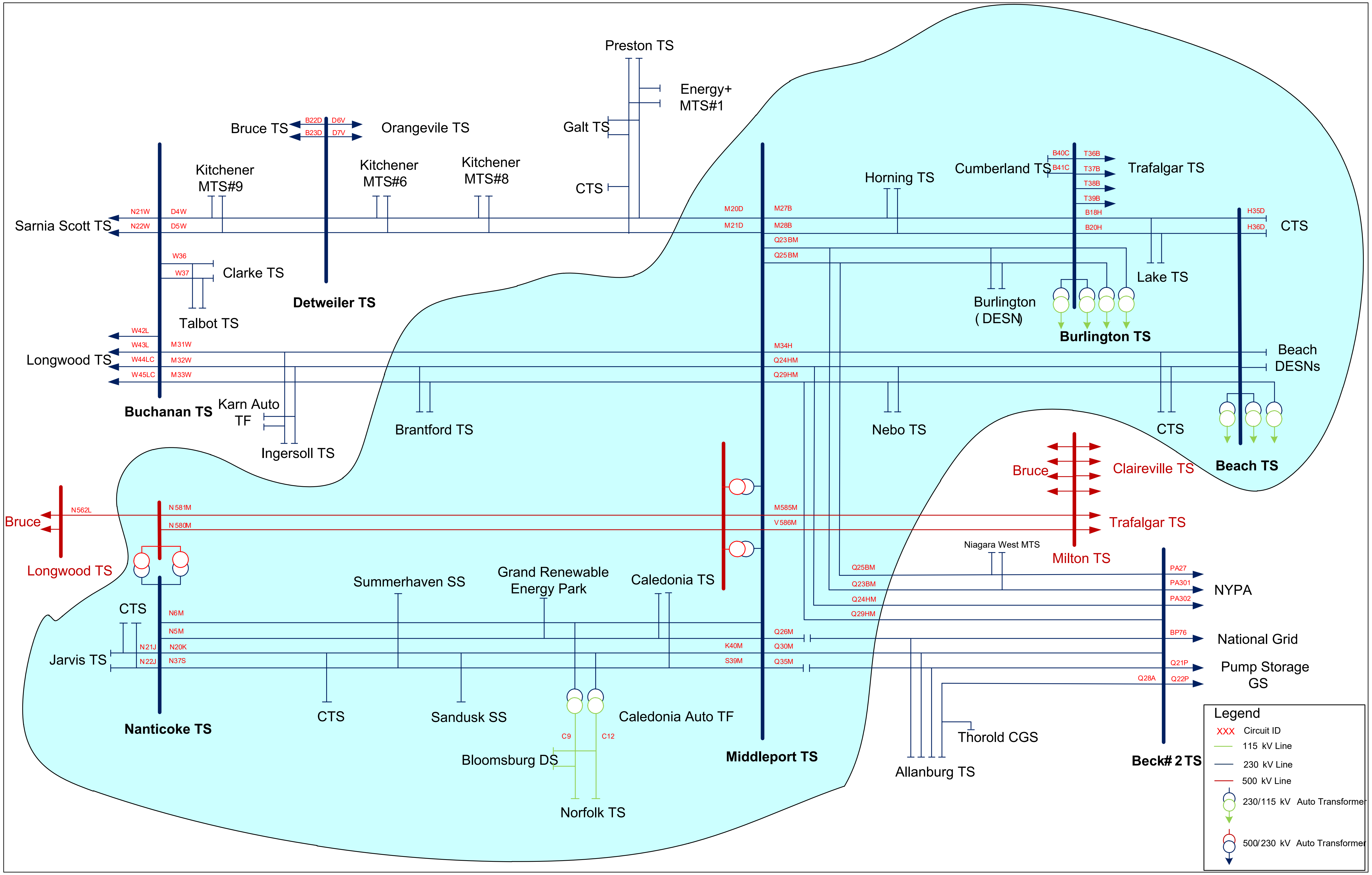

Figure 3-5 Burlington to Nanticoke Region 500 & 230 kV and Caledonia-Norfolk 115 kV Network

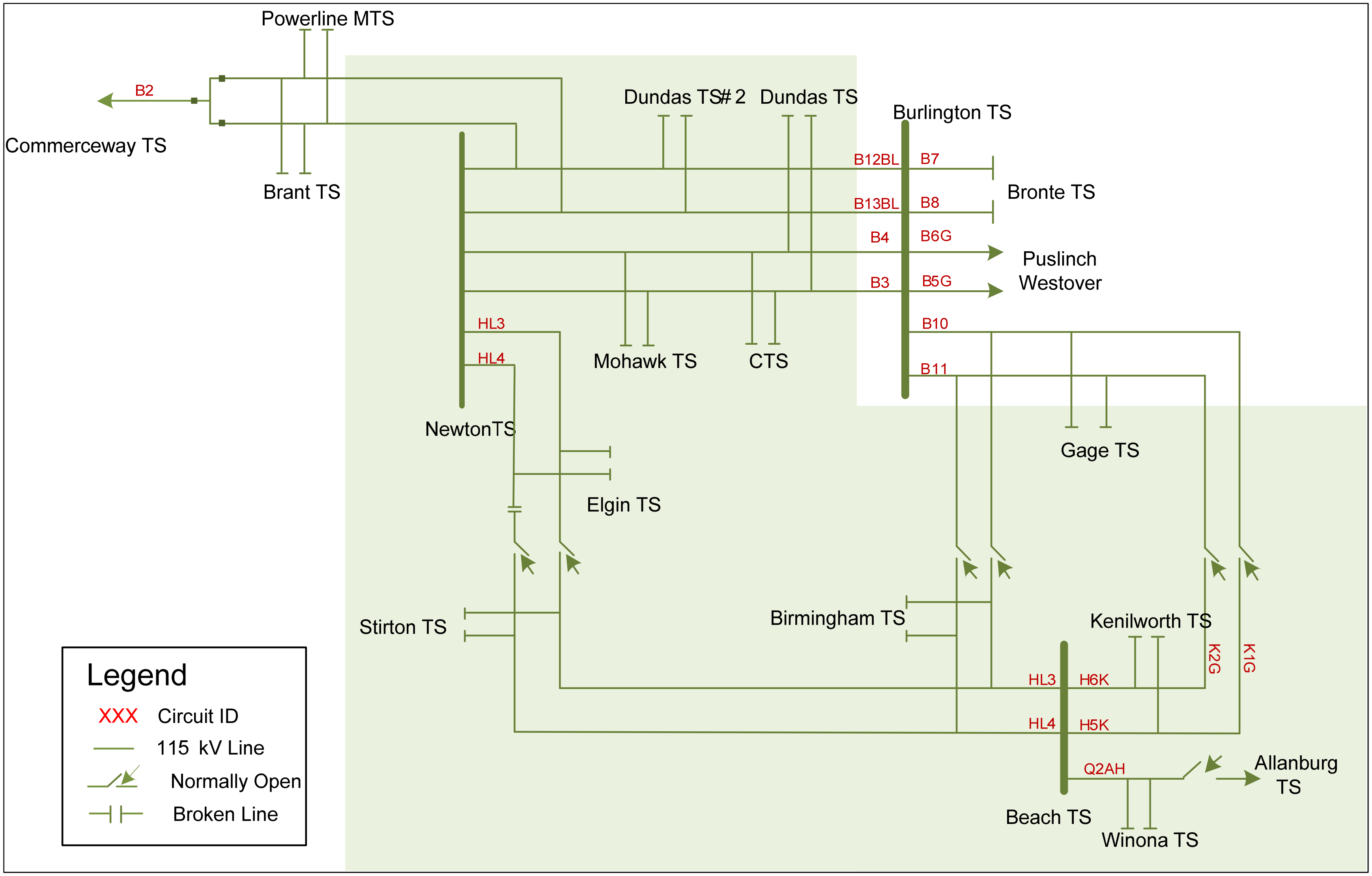

Figure 3-6 115 kV Network Supplied by Burlington TS and Beach TS

4. TRANSMISSION FACILITIES COMPLETED OVER LAST TEN YEARS

OVER THE LAST 10 YEARS A NUMBER OF TRANSMISSION PROJECTS HAVE BEEN PLANNED AND COMPLETED BY HYDRO ONE, IN CONSULTATION WITH THE LDCs AND/OR THE IESO, AIMED TO MAINTAIN OR IMPROVE THE RELIABILITY AND ADEQUACY OF SUPPLY IN THE BURLINGTON TO NANTICOKE REGION.

A brief listing of some of the major projects completed over the last ten years are as follows:

- Burlington TS (2009) - replaced 230/115 kV autotransformer T6 following failure.
- Second 115 kV supply to Norfolk TS and Bloomsburg DS (2009) – Built 12 km of new 115 kV circuit to provide second supply to Norfolk TS and Bloomsburg DS.
- Jarvis TS (2011) and Caledonia TS (2012) – installed LV reactors to reduce short circuit levels below the TSC limits and to allow increased generation connection capability at these stations.
- Nebo TS (2013) – replaced 230/ 27.6 kV transformers (T1/T2) with larger size standard units and added six new breaker positions to meet customer needs.
- Burlington TS (2016) – installed an additional 230 kV circuit breaker to reduce probability of the simultaneous loss of two autotransformers to improve supply reliability of the stations supplied from 115 kV bus.
- Transformer replacement at stations: Norfolk TS (2009), Birmingham TS (2010), Cumberland TS (2012), Brantford TS (2013), Kenilworth TS (2014), Dundas TS (2015), Brant TS (2016), Beach TS (2018) and Mohawk TS (2018).
- B7/B8 115 kV Transmission line capacity (2018) – addressed supply capacity constraint to Bronte TS through distribution load transfers (Ongoing)
- Horning TS (2018) – replaced 230/ 13.8 kV transformers (T1/T2) & LV switchgears
- Bronte TS (2019) – replaced 115/ 27.6 kV transformers (T5/T6) & associated LV switchgears
- Brant Switching Station (2019) – installed three (3) 115 kV breakers at Brant TS integrating 115 kV B12BL/B13BL circuits with 115 kV B2 circuit from Karn TS, to provide additional supply capacity for Brant TS and Powerline MTS.

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5. FORECAST AND OTHER STUDY ASSUMPTIONS

5.1 Load Forecast

The load in the Burlington to Nanticoke Region is growing at a slow rate of about 1% annually. However the loads at Norfolk TS and Bloomsburg DS mark a significant growth over the study period due to the high penetration of greenhouse loads and developments in Brant and Hamilton sub-regions.

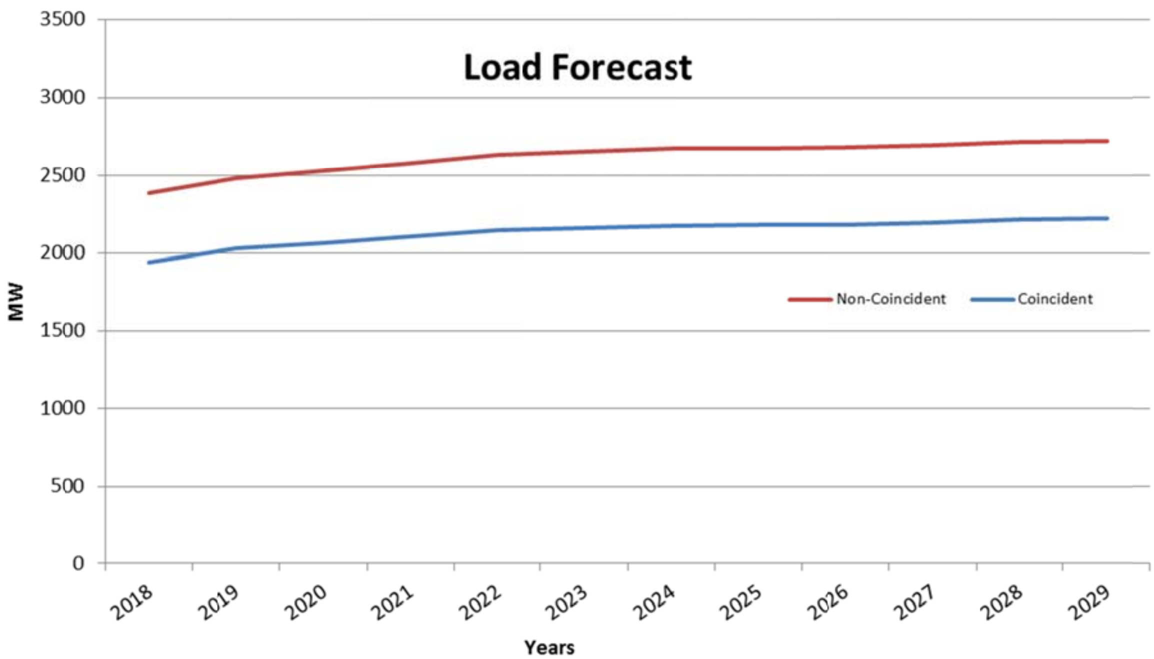

Figure 5-1 Burlington to Nanticoke Region Summer Extreme Weather Peak Forecast

Figure 5-1 shows the Burlington to Nanticoke Region peak summer non-coincident load forecast. The non-coincident and coincident load forecasts were prepared based on the 2018 extreme weather corrected loads. The non-coincident forecast represents the sum of the individual station's peak load and is used to determine the need for stations and the coincident load forecast was used to determine line capacity needs. Regional non-coincident and coincident load forecasts for the Burlington to Nanticoke Region are given in Appendix D.

The RIP load forecast was developed as follows:

- Load forecast for all stations was developed using the summer 2018 actual peak load adjusted for extreme weather and applying the station net growth rates provided by the LDCs. The net station loads account for CDM measures and connected DG in the region.

5.2 Other Study Assumptions

The following other assumptions are made in this report.

- The study period for the RIP assessments is 2019-2029.
- All planned facilities listed in Section 4 are assumed to be in-service.
- Summer is the critical period with respect to line and transformer loadings. The assessment is therefore based on summer peak loads.
- Station capacity adequacy is assessed by comparing the non-coincident peak load with the station's normal planning supply capacity, assuming a 90% lagging power factor for stations having no low-voltage capacitor banks and 95% lagging power factor for stations having low-voltage capacitor banks.
- Line capacity adequacy is assessed by using coincident peak loads in the area.
- Normal planning supply capacity for transformer stations in this sub-region is determined by the Hydro One summer 10-Day Limited Time Rating (LTR).
- Adequacy assessment is conducted as per Ontario Resource Transmission Assessment Criteria (ORTAC).

6. ADEQUACY OF FACILITIES

THIS SECTION REVIEWS THE ADEQUACY OF THE EXISTING TRANSMISSION AND DELIVERY STATION FACILITIES SUPPLYING THE BURLINGTON TO NANTICOKE REGION OVER THE 2019-2029 PERIOD.

Within the current regional planning cycle three regional assessments have been conducted for the Burlington to Nanticoke Region. These studies are:

1) NA Report - Burlington to Nanticoke Region, May 15 , 2017
2) SA Report – Burlington to Nanticoke Region, August 25, 2017
3) IRRP Report – Hamilton sub-region, February 25, 2019

The NA and IRRP reports identified a number of needs to meet the forecast load demands and asset approaching EOL. A review of the loading on the transmission lines and stations in the Burlington to Nanticoke Region was also carried out as part of the assessment using the latest regional load forecast provided in Appendix D. Sections 6.1 to 6.5 present the results of this review. Further description of assessments, alternatives and preferred plan along with status is provided in Section 7.

6.1 500 and 230 kV Transmission Facilities

The 500 kV and most of the 230 kV transmission circuits in the Burlington to Nanticoke Region are classified as part of the Bulk Electricity System ("BES"). They connect the Region to the rest of Ontario's transmission system. A number of these circuits also serve local area stations within the region and the power flow on them depends on the bulk system transfers as well as local area loads. In addition there are three 230 kV double circuit lines H35D/ H36D, B40C/ B41C and N21J/ N22J that supply only local loads. The circuits supplying local loads in the region are as follows (refer to Figure 3-5):

Terminal Stations	Circuits	Connected Supply Stations
Middleport TS to Burlington TS	M27B/ M28B	Horning TS
Middleport TS to Beck #2 TS to Burlington TS	Q23BM/ Q25BM /Q24HM/ Q29HM	Burlington (DESN) TS, Nebo TS and a CTS
Middleport TS to Buchanan TS	M32W/ M33W	Brantford TS
Middleport TS to Nanticoke TS	N5M/ S39M/ N20K	Caledonia TS and a CTS
Burlington TS to Beach TS	B18H/ B20H	Lake TS
Nanticoke TS to Jarvis TS	N21J/ N22J	Jarvis TS and a CTS
Beach TS to a CTS	H35D/ H36D	CTS
Burlington TS to Cumberland	B40C/ B41C	Cumberland TS

6.2 230/115 kV Transformation Facilities

Almost half of the Region's load is supplied from the 115 kV transmission systems. The primary source of 115 kV supply is from three 230/115 kV autotransformers at Burlington TS, Beach TS and Caledonia TS.

Table 6-1 summarizes the loading levels for all three 230 /115 kV auto transformers in the Burlington to Nanticoke region.

Table 6-1 Adequacy of 230/115 kV Autotransformer Facilities

Facilities	MVA Load Meeting Capability	2018 MVA Loading	Need Date
Burlington TS 230/115 kV autotransformers	912	560	-[(1)]
Beach TS 230/115 kV autotransformers	582	268	-[(1)]
Caledonia TS 230/115 kV autotransformer	187	104	-[(1)]

[(1)] Adequate over the study period (2019- 2029)

The autotransformers in the Burlington to Nanticoke region are of adequate capacity over the study period (2019-2029). The installation of the 230/115 kV autotransformers at Cedar TS in 2017 have reduced the loading on the Burlington autotransformers. The recently in-service 115 kV switching at Brant TS will further reduce loading on the Burlington TS autotransformers.

The loading on the Burlington TS 230/115 kV autotransformers, for the simultaneous loss of two autotransformers, is therefore expected to remain within the short term rating of the two remaining in-service autotransformers at Burlington TS. No further action is required.

6.3 115 kV Transmission Facilities

The 115 kV transmission facilities can be divided in three main sections: Please see Figure 3-5 and 3-6 for the single line diagrams.

1. Burlington 115 kV – has twelve 115 kV circuits B3/B4, B5/B6, B7/B8, B10/B11, B12BL/B13BL and HL3/ HL4. The supply capacity of Burlington 115 kV lines is adequate over the study period (2019-2029). The HL3/ HL4 115 kV double circuit cable consist of two sections:
    i. HL3/ HL4 Newton TS to Elgin TS
    ii. HL3/ HL4 Elgin TS to Stirton TS (HL4 is idle)

These cables provide normal and backup supply to Elgin TS. The supply capacity of 115 kV HL3/ HL4 cables is adequate over the study period (2019-2029).

2. Beach 115 kV– has five 115 kV circuits H5K/ H6K, HL3/ HL4 and Q2AH out of Beach TS serving the area. In addition there are two115kV circuits K1G and K2G connecting Kenilworth TS to Gage TS. These circuits are normally open and provide backup supply.

   The supply capacity of Beach 115 kV cables and lines is adequate over the study period (2019-2029).

3. Norfolk Caledonia – has two 115 kV circuits C9 and C12 supplying Norfolk TS and Bloomsburg DS. The need of additional supply capacity for C9/C12 double circuit line was identified during the earlier phases of the regional planning cycle.

   The updated load forecast and further assessment as part of this RIP shows that the combined load of Norfolk TS and Bloomsburg DS exceeds the 87 MW supply capacity of C9/ C12 line. This need is further discussed in this RIP (Section 7).

   The loading on the limiting 115 kV circuits is summarized below in Table 6-2.

Table 6-2 Limiting Sections of 115 kV Circuits

Line Section	Overloaded Circuit	Reference Section	Capacity (MW)	Contingency	2018 Loading (MW)	Need Date
Caledonia TS to Norfolk TS	C9/ C12	Section 7.9	87	C9/ C12	94*	2019

*Local coincident peak. Excess loads being transferred to Jarvis TS

The adequacy of 115 kV lines capacity was assessed using 2018 Summer Peak base case updated with 2029 loading.

The list of all the 230 kV and 115 kV circuits is given in Appendix A.

6.4 Step-Down Transformation Facilities

There are a total of 29 step-down transmission connected transformer stations in the Burlington to Nanticoke Region. The stations have been grouped based on the geographical area and supply configuration. The station loading in each area and the associated station capacity is provided in Table 6-3 below. The complete list of all the stations in the Burlington to Nanticoke region and their supply circuits is given in Appendix B.

Table 6-3 Adequacy of Step-Down Transformer Stations

sub-region	Capacity (MW)	2018 Loading (MW)	Need Date
Brant sub-region	403	289	-(2)
Bronte sub-region	540	401	-(2)
Greater Hamilton sub-region (1)	2017	1092	-(2)
Caledonia Norfolk sub-region (1)	344	203	-(3)

(1) Excludes Customer Transformer Stations (CTS)
(2) Adequate over the study period (2019-2029)
(3) Near term and mid to long term needs, for details refer to section 7.

Dundas TS has two DESN units T1/T2 and T5/T6. The T1/T2 DESN at Dundas TS is loaded over its supply capacity due to unbalanced loading between the two Dundas TS DESNs. The total supply capacity of both the Dundas TS DESNs is sufficient over the study period. The loading between the two Dundas TS DESNs is required to be balanced.

Nebo TS 13.8 kV T3/T4 DESN was also identified as marginally over loaded during an earlier phase of the regional planning cycle. Further assessment as part of this RIP based on updated forecast confirms that the loads on the Nebo TS T3/T4 DESN will remain around its supply capacity during the study period. No further action is required.

Bloomsburg DS is currently forecasted to reach its limit by 2022 but Norfolk TS has adequate station supply capacity over the study period. However, the supply circuit C9/C12 is constrained and a mid-term to long term solution will be required.

6.5 System Reliability and Load Restoration

In case of contingencies on the transmission system, ORTAC provides the load restoration requirements relative to the amount of load affected. Planned system configuration must not exceed 600 MW of load curtailment/rejection. In all other cases, the following restoration times are provided for load to be restored for the outages caused by design contingencies.

a. All loads must be restored within 8 hours.
b. Load interrupted in excess of 150 MW must be restored within 4 hours.
c. Load interrupted in excess of 250 MW must be restored within 30 minutes.

It is expected that all loads can be restored within 8 hours in the Burlington to Nanticoke Region over the study period. None of the transmission circuits in the Burlington to Nanticoke region will be supplying total loads in excess of 250 MW. The following double circuit lines in the Burlington to Nanticoke Region are expected to supply the loads in excess of 150 MW at peak times:

- B3/ B4
- B12BL/ B13BL
- H35D/ H36D

- M32W/ M33W
- Q23BM/ Q25BM

These circuits are located in urban and semi urban areas and are well accessible in the events of emergencies. Therefore based on the past performance and reliability data, the restoration criteria are met and the Study Team recommends that no further action is required at this time.

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7. REGIONAL NEEDS & PLANS

THIS SECTION DISCUSSES ELECTRICAL INFRASTRUCTURE NEEDS IDENTIFIED IN THE PREVIOUS REGIONAL PLANNING CYCLE, THE NEEDS ASSESSMENT REPORT FOR THIS CYCLE, SCOPING ASSESSMENT AND THE HAMILTON SUB-REGION IRRP; AND SUMMARIZES THE PLANS DEVELOPED TO ADDRESS THESE NEEDS.

This section outlines and discusses infrastructure needs and plans to address these needs for the near-term (up to 5 years) and the mid-to long-term (beyond 5 years) planning horizon. This includes long-term needs associated with sustainment plan. The long term needs will be assessed in the next planning cycle.

The near-term (2019-2024) electrical infrastructure needs in the Burlington to Nanticoke Region are summarized below in Table 7-1.

Table 7-1 Identified Near-Term Needs in Burlington to Nanticoke Region

No.	Needs	Section	Timing
1	Cumberland TS: Power factor correction	7.1	2019
2	115 kV B7/B8: EOL line section from Burlington TS to Nelson Jct.	7.2	2020
3	115 kV B3/B4: EOL line section from Horning Mountain Jct. to Glanford Jct.	7.3	2020
4	Elgin TS: EOL transformers & switchgears	7.4	2021
5	Newton TS: EOL transformers	7.5	2021
6	Kenilworth TS: EOL transformer & switchgear	7.6	2021
7	Dundas TS: Load transfers	7.7	2021
8	Gage TS: EOL transformers & switchgear	7.8	2021
9	Kenilworth TS: Power factor correction	7.9	2022
10	Norfolk area supply capacity	7.10	2023

Note: Further condition assessment did not confirm the earlier identified need of refurbishing Brantford switchgear.

The mid- and long-term (beyond 2025) electrical infrastructure needs in the Burlington to Nanticoke Region are summarized below in Table 7-2. Where available, a preliminary plan to address that need is provided in the corresponding sub-section.

Table 7-2 Identified Mid- and Long-Term Needs in Burlington to Nanticoke Region

No.	Needs	Section	Timing
1	Birmingham TS: EOL transformer and metalclad switchgears	7.11	2025
2	Mid-Term EOL transformers at Nebo TS (T3/T4), Caledonia TS (T1) and Jarvis TS (T3/T4)	7.12	2025-29
3	Mid-Term EOL switchgears at Norfolk TS and Burlington TS	7.13	2026
4	EOL cables in Hamilton sub-region: H5K/H6K, K1G/K2G, HL3/HL4	7.14	2026
5	Norfolk area supply capacity: Install new 230 kV double circuit lines and a new DESN	7.10	2026
6	Beach TS: EOL 230 kV auto-transformers and DESN transformers	7.15	2027
7	Lake TS: EOL transformers and switchgear	7.16	2027
8	Burlington TS: EOL 230 kV auto-transformer	7.17	2030

The needs identified in the Burlington to Nanticoke Region in the above Tables 7-1 and 7-2 are further discussed below.

7.1 Cumberland TS: Power Factor Correction

7.1.1 Description

The Cumberland TS supplies about 120 MW of loads in the city of Burlington. The historical loading data of Cumberland TS indicated that under peak load conditions the power factor at Cumberland TS is lagging slightly below the ORTAC requirement of 0.9.

7.1.2 Recommended Plan and Current Status

The Needs Assessment report identified this need and Study Team recommended Burlington Hydro to work with their load customers supplied by Cumberland TS and install capacitor banks on distribution system required to meet the minimum power factor requirement of 0.9.

A Burlington Hydro customer supplied by Cumberland TS has recently installed capacitor banks within its facilities to improve the power factor. This is expected to address the power factor need at Cumberland TS. However, the Study Team recommends that Hydro One and Burlington Hydro continue monitoring the power factor at this station.

7.2 115 kV Circuits B7/B8: End of Life Section (Burlington TS to Nelson Junction)

7.2.1 Description

The 115 kV double circuit line B7/B8 line supplies about 140 MW of Burlington and Oakville area loads through Bronte TS. The line section from Burlington TS to Nelson junction (about 2.3 km) was built in 1920's. Hydro One has identified that the conductor on this line section from Burlington TS to Nelson junction has reached end of useful life.

7.2.2 Alternatives and Recommended Plan

The following alternatives were considered to address 115 kV B7/B8 end of life line section from Burlington TS to Nelson junction:

- <u>Maintain status quo</u>: This alternative was considered and rejected as it does not address the EOL issue, risk of failures resulting in poor supply reliability and would result in increased maintenance expenses.
- <u>Refurbishment of EOL line section</u>: Refurbish 2.3 km of EOL line conductor section of B7/B8 line section.

The Study Team recommendation is to refurbish the 115 kV B7/ B8 line section from Burlington TS to Nelson junction supplying Bronte TS using similar ACSR conductor. The refurbishment work is expected by Hydro One to be completed by 2020 at an estimated cost of approximately $2 million.

7.3 115 kV Circuits B3/B4: End of Life Section (Horning Mountain Jct. to Glanford Jct.)

7.3.1 Description

The 115 kV B3/B4 line supplies Hamilton sub-region loads including Dundas TS (T1/T2 DESN) and Mohawk TS. The 11 km long from Horning Mountain Jct. to Glanford Jct. section of this line has a solid copper conductor which is approximately 100 years old and at end of useful life.

7.3.2 Alternatives and Recommended Plan

The following alternatives were considered to address the above need:

- <u>Continue to maintain the assets (status quo)</u>: This alternative was considered and rejected as it does not address the frequent failure, increased maintenance expenses and poor supply reliability.
- <u>Refurbishment of EOL line section</u>: Refurbish this line section and replacing EOL copper conductor with 605 kcmil ACSR conductor on this line tap section.

The Study Team recommends Hydro One to continue refurbishment of this line section and replace copper conductor with 605 kcmil ACSR from Horning Mountain Jct. to Glanford Jct. supplying Mohawk TS. This work is currently expected to be completed in 2020 at an estimated cost of $21 million.

7.4 Elgin TS: End of Life Transformers and Switchgears

7.4.1 Description

Elgin TS consists of two DESNs (T1/T2 and T3/T4) built in 1960's supplying loads in the city of Hamilton through three switchgears. The 2018 peak load at Elgin TS was approximately 98 MW.

The T1/T2 transformers are 75 MVA units while the T3/T4 units are non-standard 33 MVA units. All existing four transformers (T1, T2, T3, and T4) and three switchgears at Elgin TS have been identified by Hydro One as approaching end of their useful life. This need was identified in the Needs Assessment phase.

7.4.2 Alternatives, Recommended Plan and Current Status

The following alternatives were considered to address end of life issues at Elgin TS:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition, safety issues and would result in increased maintenance expenses and will not meet Hydro One's obligation to provide reliable supply to the customers.
- "Like-for-Like" replacement of the assets: This alternative would continue maintaining four transformers and the associated three switchgears. This option is extremely costly and cannot be justified with load forecast not showing any growth at this station.
- Station/load consolidation: Moving loads to neighboring station(s) and retiring Elgin TS. This alternative was considered but is not feasible due to limited load transfer capacity with neighboring stations and higher costs associated with load transfers.
- Reconfiguration and downsize the station from two DESNs to one DESN station: In this option, the station will be reconfigured and downsized from the existing four transformers to two transformers.

The Study Team recommends Hydro One to proceed with the reconfiguration of the station and reduce it to two transformers and two switchgears only. Under this plan, T1/T2 and T3/T4 DESNs will be replaced by a single T5/T6 DESN with two 100 MVA standard units and four new switchgears. This will maintain adequate supply capacity to the loads. This plan is expected to cost $81 million with an expected in service of 2021.

7.5 Newton TS: End of Life Transformers

7.5.1 Description

Newton TS is a 115 / 13.8 kV DESN station built in 1956 and supplies Alectra Utilities loads in the city of Hamilton. The current load at Newton TS is approximately 52 MW, and is expected to stay at this level over the study period.

The T1/T2 transformers are 67 MVA nonstandard units, supplying loads through 13.8 kV switchgears. Both these transformers have been identified as EOL requiring replacement. Recently the transformer T2 has failed and is being replaced on an emergency basis and transformer T1 is also showing signs of deterioration.

7.5.2 Alternatives and Recommended Plan

The following alternatives are considered in the light of recent developments with regards to end of life asset at Newton TS:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance cost.
- Station/load consolidation: Moving loads to neighboring station(s) and retiring Newton TS. This alternative was considered but is not feasible due to stations' geographic location separating it from the neighboring 13.8 kV distribution system.
- Replacement of the assets: Replace existing 67 MVA Newton TS companion transformer T1 with 75 MVA units built to current standards.

The Study Team recommends to replace existing 67 MVA Newton TS transformer T1 with 75 MVA unit similar to T2 built to current standards to ensure reliability of supply for the customers in the area. This replacement work at Newton TS is currently planned to be completed by 2021.

7.6 Kenilworth TS: End of Life Transformer and Switchgear

7.6.1 Description

The two DESNs at Kenilworth TS are over 60 years old, supplying 52 MW load in the city of Hamilton. The T1/T4 DESN transformers are non-standard 67 MVA units. The transformer T2 of second DESN is rated at 100 MVA while T3 is a non-standard 120 MVA unit.

The original T2 transformer failed in 2014 and was replaced with a standard 100 MVA unit. The remaining three transformers (T1, T3, and T4) and one of the two in service switchgears at Kenilworth TS have been identified as approaching end of their useful life.

7.6.2 Alternatives and Recommended Plan

The following alternatives were considered to address end of life issue at Kenilworth TS:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance expenses and reduce supply reliability to the customers.
- "Like-for-Like" replacement of the assets: This alternative would require maintaining four transformers and the associated three switchgears which is not justifiable based on the load forecast.

- Station/load consolidation: Moving loads to neighboring station(s) and retiring Kenilworth TS. This alternative was considered but is not feasible due to: a) unique electrical characteristics and requirements of industrial costumer load in the area, and b) higher costs associated with reconfigurations and transfer of customer loads.
- Reconfiguration of the station reducing to two supply transformers and two switchgears: This option will reconfigure and adequately downsize the station. In this configuration, station will be reduced from four transformers to only two transformers supplying two switchgears.

The Study Team recommends Hydro One proceed with the last option above and reconfigure the station, reducing it to a single DESN with two transformers and two switchgears. The recently replaced transformer and one of the existing metalclad switchgear will be utilized while one transformer and switchgear will be replaced. The new transformer T3 will be a standard unit similar to T2 that was replaced in 2014. This refurbishment project is currently expected to be completed by the year 2021 at an estimated cost of $35.8 million.

7.7 Dundas TS: Load Transfer

7.7.1 Description

Dundas TS (T1/T2) and Dundas TS #2 (T5/T6) are supplying a total peak load of 150 MW in the city of Hamilton. The total supply capacity of both stations is 188 MW which is sufficient over the study period.

The loading at Dundas TS will be capped at its supply capacity of 99 MW and any additional loads will be supplied from Dundas TS #2. Hydro One distribution currently supplied from the Dundas TS is planning to transfer any excess load to Dundas TS #2.

7.7.2 Alternatives, Recommended Plan and Current Status

The following alternatives were considered to address customer's needs:

- Maintain status quo: This alternative was considered and rejected as it does not address the DESN's load balancing and customer's needs.
- Transfer customer load to Dundas TS #2: Move off loads in excess to the supply capacity of Dundas TS to Dundas TS #2. To facilitate this, two new feeder positions are required at Dundas TS #2. These new breaker positions will be also used to meet future load growths. This option will require reconfiguring of distribution assets by the LDCs.

The Study Team recommends the option to transfer excess load from Dundas TS to Dundas TS #2 by the LDCs utilizing two additional breaker positions at an estimated cost of $2 million, by 2021. It is estimated that LDCs will have to invest approximately $9 million in distribution infrastructure to fully implement this plan.

7.8 Gage TS: End of Life Transformers and Switchgear

7.8.1 Descriptions

Gage TS has three DESNs (T3/T4, T5/T6, and T8/T9) predominantly supplying large industrial customer loads in Hamilton. T3/T4 and T5/T6 DESNs were built in the 1940's with each transformer rated at 63 MVA LTR, while T8/T9 DESN was built in 1960's with each transformer rated at 137 MVA LTR.

These transformers are non-standard units meeting unique high short circuit requirements of the customers. The transformers T3, T4, T5, and T6, as well as T8/T9 DESN switchgear at Gage TS have been identified at their EOL. The refurbishment of these assets has been previously deferred to better understand customer load requirements. Transformer T5 and breakers in the T5/T6 DESN have experienced recurring problems.

The load at Gage TS has reduced over the years to approximately 50 MW, and is currently expected to stay at around this level over the study period. The existing station capacity (of the three DESNs) is about 240 MW. Although there seems to be over-capacity at Gage TS, unique short-circuit and connection requirements of industrial loads at this station limits the feasibility of some of the alternatives/solutions.

7.8.2 Alternatives, Recommended Plan and Current Status

The following alternatives were considered to address end of life issues at Gage TS:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition, safety issues and would result in increased maintenance expenses and will not meet Hydro One's obligation to provide reliable supply to the customers.
- "Like-for-Like" replacement of the assets: This alternative would continue maintaining six transformers and the associated three switchgears. This option is extremely costly and cannot be justified since the load has significantly reduced at this station.
- Station/load consolidation: Moving loads to neighboring station(s) and retiring Gage TS. This alternative is not feasible due to: a) unique costumer load requirements (i.e., high short circuit currents are required to operate customer's large arc furnaces and large motors without significant impact to power quality), and b) higher costs associated with reconfigurations of LV cables and transfer of customer loads to other stations.
- Reconfiguration of the station and downsize the station from three DESN to two DESN station: In this option, the station will be reconfigured and downsized from the existing six transformers to four transformers.

The Study Team recommends that Hydro One proceed with the reconfiguration of the station, reducing it from 3 DESNs to 2 DESNs. This plan also provides future flexibility to eliminate the T8/T9 DESN when it approaches EOL. Under this plan, T3/T4 and T5/T6 DESNs will be replaced by a single T10/T11 DESN with two 100 MVA standard units. It also includes replacement of switchgear currently supplied from the T5/T6 transformers.

The refurbishment of Gage TS is expected to be completed in 2021 at an estimated cost of $55 million.

7.9 Kenilworth TS: Power Factor Correction

7.9.1 Description

There are two supply stations inside Kenilworth TS T1/T4 and T2/T3 supplying about 52 MW of loads in the city of Hamilton. The historical loading data of Kenilworth TS indicated that under peak load conditions the power factor at Kenilworth TS is lagging below the ORTAC requirement of 0.9.

7.9.2 Alternatives and Recommended Plan

The following alternatives were considered to address the power factor need at Kenilworth TS:

- Maintain status quo: This alternative was considered and rejected as it does not address the need to meet the ORTAC power factor requirement.
- Improve power factor on distribution system: Install capacitor bank/s and/or work with load customers supplied by Kenilworth TS.

This need was identified during the last Regional Planning cycle and the Study Team recommended Alectra Utilities to install capacitor bank and/or work with load customers supplied by Kenilworth TS to meet ORTAC power factor requirement of 0.9.

The installation of capacitor bank will be initiated after completion of refurbishment of Kenilworth TS in 2021 at an estimated cost of $1 million in 2022.

7.10 Norfolk Area Supply Capacity

7.10.1 Description

Norfolk area is currently supplied by two 115 / 27.6 kV DESNs, Norfolk TS and Bloomsburg DS through 115 kV double circuit supply (C9/C12) from Caledonia TS. Both Norfolk TS and Bloomsburg DS have two identical 115 / 27.6 kV transformers of 83 MVA and 42 MVA respectively and are less than 20 years old. The area supply capacity is limited to 87 MW by voltage decline limit in the event of loss of one the two (C9 or C12) supply circuits. The 2018 total peak load of Norfolk area was 94 MW, approximately 7 MW over the supply capacity.

This area has recently seen a significant interest from greenhouse developers and the loads are expected to grow significantly over the study period as identified during this RIP by the study team.

By the year 2021-22, the net load growth of around 20 MW is envisaged and will require supplementing the 115 kV supply system. Over the study period, the net load growth of about 55 MW is forecasted which would be above the thermal limit of 139 MVA for the existing 115 kV transmission line.

7.10.2 Alternatives and Recommended Plan

The following alternatives are considered to address the future supply needs of Norfolk area:

- Maintain status quo: This alternative was considered and rejected as it does not address the customer's needs in the area.
- Near Term Options/Solutions:
    - Install capacitor banks: Install capacitor banks at Norfolk TS to improve voltage profile increasing supply capacity of area to accommodate approximately 10 MW of expected load increases in the near term
    - Transfer loads from Norfolk area to nearby stations using existing feeders: There is limited load transfer capacity available between the Norfolk area stations and Jarvis TS. New feeder inter-ties may need to be built to transfer around 5 MW of load from Norfolk area to Jarvis TS.
- Mid- to Long Term Options/Solution:
    - Converting C9/ C12 115 kV circuits to 230 kV: Upgrading 115 kV C9/C12 circuits to 230 kV will impart additional transmission capacity beyond the current capacity of 87 MW. However, this option will have line capacity limitation along with implementation challenges.
    - New 230 kV double circuit line about 20-25 km long and a new 230/ 27.6 kV DESN: A new station in Norfolk area supplied by a new 230 kV double circuit line by either tapping two 230 kV circuits in the Middleport TS to Nanticoke TS or Middleport TS to Buchanan TS corridor.

The Study Team recommends that in the near term a) Hydro One install new additional capacitor bank at Norfolk TS in 2022 and b) LDCs build feeder inter-ties to transfer load between the Norfolk area stations and Jarvis TS. Hydro One transmission will plan capacitor bank to be connected in 2022 at an estimated cost of $3 million.

The Study Team recommends further assessment be carried out by the IESO and Hydro One to review that mid to long term options identified above and develop a recommended plan to address the capacity needs for the Norfolk Area in advance of the next planning cycle. Following the assessment, an addendum will be included to the IRRP and RIP reports in 2020.

7.11 Birmingham TS: End of Life Transformer and Switchgears

7.11.1 Description

Birmingham TS is located in the city of Hamilton having two DESN units T1/T2 and T3/T4 of 75 MVA each. Both the DESNs at Birmingham TS can supply a total load of about 185 MVA (LTR). The Birmingham TS currently supplies a large industrial customer with unique connection requirements. The load at Birmingham TS is forecasted at about 90 MW over the study period.

At this time one 115 / 13.8 kV transformer and three 13.8 kV LV metalclad switchgears are at EOL and have been identified by Hydro One for refurbishment.

7.11.2 Alternatives and Recommended Plan

The following alternatives are considered to address Birmingham TS end of life asset needs:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance cost.
- Station/load consolidation: Moving loads to neighboring station(s) and retiring Birmingham TS. This alternative was considered but is not feasible due to customer's unique needs.
- Replacement of the assets: Replace existing T1 EOL transformer with similar unit and three metalclad switchgears to current standards.

The Study Team recommends to replace the end of life T1 transformer and three 13.8 kV LV metalclad switchgears at Birmingham TS to meet the unique connection needs of the customer at this station with similar equipment and. Currently, Hydro One expects to complete this replacement by 2025.

7.12 Mid-Term End of Life Transformer Replacements

7.12.1 Description

Hydro One has identified the following transformers reaching end-of-life in the 2025 – 2029 timeframe:

1. Nebo TS (T3/T4)
2. Caledonia TS (T1)
3. Jarvis TS (T3/T4)

7.12.2 Alternatives and Recommended Plan

The following alternatives are considered to address the above end of life asset needs:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance cost.
- Station/load consolidation: Moving loads to neighboring station(s) and retiring these stations. This alternative was considered but is not feasible as there were no nearby stations that can accommodate their loads.
- Replacement of the assets: Replace existing transformers with similar units built to current standards.

The option for these needs is like-for-like replacement of transformers. However, as these needs are far in future, the Study Team recommends reviewing these needs again in the next regional planning cycle.

7.13 Mid-Term End of Life LV Switchgear Replacement

7.13.1 Description

Hydro One has identified that the LV switchgears at a number of stations are reaching end-of-life in the 2025 – 2029 timeframe and need to be replaced. These stations are:

1. Norfolk TS
2. Burlington TS

7.13.2 Alternatives and Recommended Plan

The following alternatives are considered to address the above end of life asset needs:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance cost.
- Replacement of the assets: Replace existing switchgear with one's built to current standards.

The option for these needs is like-for-like replacement of switchgear. However, as these needs are far in future, the Study Team recommends reviewing these needs in the next regional planning cycle.

7.14 End of Life Cables in Hamilton Sub-region: HL3/HL4, K1G/K2G, H5K/H6K

7.14.1 Description

The Hamilton sub-region has following four (4) pairs of 115 kV underground cable circuits that are around 50 years old and approaching end of life over the next 10 years. These cables primarily supply industrial, residential and commercial loads in the City of Hamilton. These cables are also used as alternate supply during outages and emergency conditions.

i. 115 kV K1G/K2G Cable (Kenilworth TS to Gage TS)
ii. 115 kV HL3/HL4 Cable (Elgin TS to Stirton TS)
iii. 115 kV HL3/HL4 Cable (Newton TS to Elgin TS)
iv. 115 kV H5K/H6K Cable (Beach TS to Kenilworth TS)

The replacement and/or reconfiguration of these high voltage underground cables was identified in the previous cycle because it will be complicated and expensive and therefore requires assessment of alternative/s at the earliest possible as mentioned in the last regional planning.

i. 115 kV K1G/K2G Cables (Kenilworth TS to Gage TS)

These cables are 1.8 km long, of 1973 vintage connecting Gage TS and Kenilworth TS. Each of these cables is rated to supply 180 MW of loads and are used for providing backup supply to Gage TS (from Beach TS) and to Kenilworth TS (from Burlington TS) during outages and emergencies. These cables do not carry load under normal operating configuration.

Alternatives/Options

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset age and would reduce reliability of supply to the customers.
- Building a new 1.8 km overhead 115 kV double circuit corridor between Kenilworth TS and Gage TS: This option will be the least expensive but the existing route passes along the narrow road allowances and through private properties. Building new overhead line section may not be feasible due difficulty in meeting required clearances and obtaining easement rights.
- "Like-for-Like" replacement of the assets: This alternative would require replacing the existing end of life 115 kV cables with the ones of similar capacity. Although it may not be the least cost option, it is the only practical alternative.

ii. 115 kV HL3/HL4 Cable (Elgin TS to Stirton TS)

These cables are 1.9 km long, of 1968 vintage connecting Elgin TS to Stirton TS. One of the two cables (HL4) was damaged in 1998 and since then it has been out-of-service. The HL3 cable is rated at 170 MW and is used for providing backup supply to Elgin TS (from Beach TS) and to Stirton TS (from Burlington TS) during outages and emergencies. HL3 cable does not carry load under normal operating configuration.

Alternatives/Options

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset age and would reduce reliability of supply to the customers. Unavailability of this HL3 circuit at the time of need will be catastrophic.
- Building a new 1.9 km overhead long 115 kV double circuit line between Stirton TS and Elgin TS: This option will be the least expensive but the existing route passes through densely populated areas with narrow road allowances. Therefore building new overhead line section is not feasible.
- "Like-for-Like" replacement of the assets: This alternative would require replacing the existing end of life 115 kV cables with the ones of similar capacity. This is the only practical alternative but the replacement of these cables will be challenging as it passes through a densely populated areas with a number of other utilities crossing or sharing the same corridor. Further project specific assessment and details will have to be undertaken prior to initiating the project including consultation with other stakeholders, such as, municipality and other utilities on the same ROW.

iii. 115 kV HL3/HL4 Cables (Newton TS to Elgin TS)

These cables are 4.6 km long, of 1975 vintage connecting Newton TS and Elgin TS. Each of these cables is rated to supply 176 MW of loads and used for providing primary supply to Elgin TS (from Burlington TS). These cables supply about 100 MW of load at Elgin TS. For the loss of a single HL3/HL4 cable, the companion cable is sufficient to supply Elgin TS loads forecasted over the study period.

Alternatives /Options

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset age and would reduce reliability of supply to the customers.
- Building a new 4.6 km overhead 115 kV double circuit line between Newton TS and Elgin TS: This option will be the least expensive but the existing route passes through densely populated areas with narrow road allowances. This option will require section-92 application, acquiring easement rights and may still be not be feasible due to difficulty in meeting required clearances.
- "Like-for-Like" replacement of the assets: This alternative would require replacing the existing end of life 115 kV cables with the ones of similar capacity. This is the only practical alternative but the replacement of these cables will be challenging as it passes through a densely populated areas with a number of other utilities crossing or sharing the same corridor. Further project specific assessment and details will be undertaken prior to initiating the project including consultation with other stakeholders, such as, municipality and other utilities on the same ROW.

iv. 115 kV H5K/H6K Cables (Beach TS to Kenilworth TS)

These cables are 1.5 km long, of 1973 vintage connecting Beach TS and Kenilworth TS. Each of these cables is rated to supply 180 MW of loads and used for providing primary supply to Kenilworth TS (from Beach TS). These cables supply about 50 MW of load at Kenilworth TS. For the loss of a single H5K/H6K cable, the companion cable is sufficient to supply Kenilworth TS loads forecasted over the study period.

Kenilworth TS has a backup supply from Burlington TS through 115 kV K1G/ K2G cables between Kenilworth TS and Gage TS.

Alternatives /Options

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset age and would reduce reliability of supply to the customers.
- Building a new 1.5 km overhead 115 kV double circuit corridor between Kenilworth TS and Beach TS: This option will be the least expensive but the existing route passes along the narrow road allowances and through private properties. Building new overhead line section may not be feasible due difficulty in meeting required clearances and obtaining easement rights.

- “Like-for-Like” replacement of the assets: This alternative would require replacing the existing end of life 115 kV cables with the ones of similar capacity. Although it may not be the least cost option, it may be the only practical alternative.

7.14.2 Recommendation

The Study Team recommends that the above options to replace these 115 kV cables in the Hamilton Area be further assessed by Hydro One and the IESO to develop a recommended plan. After the completion of this assessment, an addendum to Hamilton Area IRRP and RIP will be incorporated in 2020.

7.15 Beach TS: End of Life 230 kV Autotransformers and DESN Transformers

7.15.1 Description

Beach TS is a major switching and transformer station in East Hamilton. Station facilities include a 230 kV switchyard, three 230/115 kV autotransformers (T1/T7/T8), a 115 kV switchyard and two T3/T4 and T5/T6 230/13.8 kV DESNs.

Hydro One has determined that all the three T1/T7/T8 autotransformers and the T5/T6 DESN transformers are expected to reach end of life by 2027 and may need to be replaced.

7.15.2 Recommended Plan

The Study Team recommends that the replacement of autotransformers to be assessed as part of the Middleport area bulk transmission planning study by the IESO in coordination with Hydro One. Since the Beach TS autotransformers are expected to require replacement in 2027, the bulk study should be planned at the earliest.

7.16 Lake TS: End of Life Transformers and Switchgears

7.16.1 Description

Lake TS is located in the city of Hamilton having two DESN units. T1/T2 DESN is a 230/27.6 kV and T3/T4 230/13.8 kV of 83 MVA and 75 MVA transformers respectively. Both the DESNs at Lake TS can supply a total load of about 230 MVA (LTR). The load at Lake TS is forecasted at about 105 MW.

At this time the T1/T2 230 / 27.6 kV transformers and both 13.8 kV and 27.6 kV LV switchgears are at their EOL and have been identified by Hydro One expected to require refurbishment in 2027.

7.16.2 Alternatives and Recommended Plan

The following alternatives are considered to address Lake TS end of life asset issue:

- Maintain status quo: This alternative was considered and rejected as it does not address the risk of failure due to asset condition and would result in increased maintenance cost.
- Replacement of the assets: Replace existing EOL transformers with similarly sized units and to meet current standards.

The Study Team is recommending that this need can be further assessed in the next regional planning cycle.

7.17 Burlington TS: End of Life 230 kV Autotransformer

7.17.1 Description

Burlington TS is a major switching and transformer station in Burlington. Station facilities include a 230 kV switchyard, four 230/115 kV autotransformers (T4/T6/T9/T12), 115 kV switchyard and a 230/27.6 kV DESN.

Hydro One has determined that autotransformer T12 is expected to reach end of life by 2030 and will need to be replaced.

7.17.2 Recommended Plan

The Study Team recommends that Burlington TS autotransformer replacement options and plan be studied as part of the Middleport area bulk transmission planning study by the IESO in coordination with Hydro One to develop a recommended plan.

7.18 Other Considerations

Municipalities in region may develop their community energy plans with a primary focus to reduce their energy consumption by local initiatives over next 25 to 30 years. With respect to electricity, these communities may plan for an increased reliance on community energy sources such as distributed generation, generation behind the meters like rooftop solar systems and local battery storage systems to reduce cost and for improved reliability of electricity supply.

There may be situations where behind the meter battery storage cannot be connected due to current connection requirements and constraints. The LDCs in Ontario and Hydro One, outside the regional planning forum, have undertaken the task of exploring the issue to assess technical constraints and /or other solutions that can facilitate connection of additional battery storage.

Some of the communities in Ontario are working towards self-sufficiency by improving efficiencies of existing local energy systems i.e. reducing energy consumption and losses by means of utilizing smarter buildings, houses, efficient heating, cooling, appliances, equipment, and processes for all community needs. Ultimately, the objective of these energy plans in the region is to be a net zero carbon community over the next 25 to 30 years.

Community energy plans may have potential to supplement and/or defer future transmission infrastructure development needs. The Study Team therefore recommends reviewing the updated regional community energy plans in the next Regional Planning cycle.

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8. CONCLUSION AND NEXT STEPS

THIS REGIONAL INFRASTRUCTURE PLAN (RIP) REPORT CONCLUDES THE REGIONAL PLANNING PROCESS FOR THE BURLINGTON TO NANTICOKE REGION.

The major infrastructure investments recommended by the Study Team for the Burlington to Nanticoke region over the near and mid -term are provided in below Table 8-1 and 8-2 respectively, along with their planned in-service date and budgetary estimates for planning purpose.

Table 8-1 Near-Term Needs/Plans in Burlington to Nanticoke Region

No.	Needs	Plans	Planned I/S Date	Budgetary Estimate ($M)
1	115 kV B7/B8: EOL line section from Burlington TS to Nelson Jct.	Refurbish the EOL B7/B8 line section	2020	2
2	115 kV B3/B4: EOL line section from Horning Mountain Jct. to Glanford Jct.	Refurbish the EOL B3/B4 line section conductor	2020	22
3	Elgin TS: EOL transformers & switchgears	Replace transformers and reduce 2 DESNs to 1 DESN	2021	81
4	Newton TS: EOL transformers	Replace EOL transformers	2021	22
5	Kenilworth TS: EOL transformer & switchgear	Reconfigure from 2 DESNs to single DESN and replace EOL equipment	2021	36
6	Dundas TS: Load transfer	Add two new feeders at Dundas TS #2	2021	2
7	Gage TS: EOL transformers & switchgear	Reduce from 3 DESNs to 2 DESNs and replace EOL equipment	2021	55
8	Kenilworth TS: Power factor correction	LDC is developing distribution option	2022	1
9	Norfolk area supply capacity	Norfolk TS: Install capacitor bank	2022	3

Table 8-2 Mid- and Long-Term Needs/Plans in Burlington to Nanticoke Region

No.	Needs	Plans	Planned I/S Date	Budgetar y Estimate ($M)
1	Birmingham TS EOL transformer and metalclad switchgears	Replace EOL equipment	2025	29
2	Mid-Term EOL transformers at Nebo TS (T3/T4), Caledonia TS (T1) and Jarvis TS (T3/T4)	Monitor and review in next planning cycle	2025-29	69
3	Mid-Term EOL switchgear at Norfolk TS and Burlington TS[5]	Monitor and review in next planning cycle	2026	57
4	EOL cables in Hamilton sub-region: H5K/H6K, K1G/K2G, HL3/HL4[6]	To further assess the options in this RIP by the Study Team and addendum issued to Hamilton IRRP and RIP	2026	28
5	Norfolk area supply capacity	To further assess the options in this RIP by the Study Team in advance of next planning cycle and addendum issued to RIP	2026	80
6	Beach TS: EOL 230 kV auto-transformers[7] and DESN transformers	To be assessed as part of Middleport Bulk Study by the IESO in coordination with Hydro One	2027	71
7	Lake TS: EOL transformers and switchgears	Monitor and review in next planning cycle	2027	45
8	Burlington TS: EOL 230 kV auto-transformer [8]	To be assessed as part of Middleport Bulk Study by the IESO in coordination with Hydro One	2030	14

Further details, alternatives, and recommended plans for the above needs are provided in Section 7.

[5] Further condition assessment did not confirm the earlier need of refurbishing Brantford switchgear.
[6] To be finalized through Hamilton IRRP Addendum by the IESO
[7] To be finalized through Middleport Bulk Study by the IESO

The Study Team recommends:

- Hydro One to continue with the implementation of major infrastructure investments listed in Table 8-1;
- Hydro One to continue with the implementation of infrastructure investments at Birmingham TS for replacement of EOL transformers and switchgears;
- The EOL 230 kV autotransformer options at Beach TS and Burlington TS will be assessed through the IESO Middleport Bulk Study in coordination with Hydro One to develop a final recommended plan;
- The EOL 115 kV Hamilton area cables options are included in this RIP. It will be further assessed by the Study Team to develop a recommended plan to be included as an addendum to the Hamilton IRRP and this RIP;
- The options to reinforce supply to the Norfolk area are included in this RIP and will be further assessed by the Study Team in advance of the next planning cycle to develop a recommended plan and an addendum be made to the RIP; and
- All the other identified needs/options in the mid and long-term will be further reviewed by the Study Team in the next regional planning cycle as discussed in Section 7.

9. REFERENCES

[1]. Independent Electricity System Operator, “Hamilton Area Integrated Regional Resource Plan”, 25 February 2019
http://ieso.ca/-/media/Files/IESO/Document-Library/regional-planning/Hamilton/Hamilton-IRRP-FINAL-February2019.pdf?la=en

[2]. Hydro One, “Needs Assessment Report, Burlington to Nanticoke Region”, 15 May 2017
https://www.hydroone.com/abouthydroone/CorporateInformation/regionalplans/burlingtontonanticoke/Documents/Needs%20Assessment_Burlington%20to%20Nanticoke_May15_2017.pdf

[3]. Hydro One, “Regional Infrastructure Plan”, 07 February 2017
https://www.hydroone.com/abouthydroone/CorporateInformation/regionalplans/burlingtontonanticoke/Documents/RIP%20Report_Burlington%20to%20Nanticoke.pdf

APPENDIX A: TRANSMISSION LINES IN THE BURLINGTON TO NANTICOKE REGION

No.	Location	Circuit Designations	Voltage (kV)
1	Beach TS - CTS	H35D, H36D	230
2	Beach TS - Burlington TS	B18H, B20H	230
3	Beach TS - Middleport TS	M34H	230
4	Beach TS - Middleport TS - Beck #2 TS	Q24HM, Q29HM	230
5	Burlington TS - Cumberland TS	B40C, B41C	230
6	Burlington TS - Middleport TS	M27B, M28B	230
7	Burlington TS - Middleport TS - Beck #2 TS	Q23BM, Q25BM	230
8	Middleport TS - Beck #2 TS	Q30M	230
9	Middleport TS - Buchanan TS	M31W, M32W, M33W	230
10	Middleport TS - Detweiler TS	M20D, M21D	230
11	Middleport TS - Nanticoke TS	N5M, N6M	230
12	Middleport TS - Summerhaven SS	S39M	230
13	Middleport TS - Sandusk SS	K40M	230
14	Nanticoke TS - Jarvis TS	N21J, N22J	230
15	Summerhaven SS - Nanticoke TS	N37S	230
16	Sandusk SS - Nanticoke TS	N20K	230
17	Beach TS - Gage TS	B10, B11	115
18	Beach TS - Kenilworth TS	H5K, H6K	115
19	Beach TS - Newton TS	HL3, HL4	115
20	Beach TS - Winona TS	Q2AH	115
21	Beach TS - CSS	H9W	115
22	Burlington TS - Brant TS	B12BL, B13BL	115
23	Burlington TS - Bronte TS	B7, B8	115
24	Burlington TS - Cedar TS	B5G, B6G	115
25	Burlington TS - Newton TS	B3, B4	115
26	Caledonia TS - Norfolk TS	C9, C12	115
27	Kenilworth TS - Gage TS (Idle)	K1G, K2G	115

APPENDIX B: STATIONS IN THE BURLINGTON TO NANTICOKE REGION

No.	Station	Voltage (kV)	Supply Circuits
1	CTS	230	H35D, H36D
2	Beach TS	230	Beach TS 230 kV Bus (1)
3	Birmingham TS	115	HL3, HL4
4	Bloomsburg DS	115	C9, C12
5	Brant TS	115	B12BL, B13BL
6	Brantford TS	230	M32W, M33W
7	Bronte TS	115	B7, B8
8	Burlington TS DESN	230	Q23BM, Q25BM
9	Caledonia TS	230	N5M, S39M
10	Cumberland TS	230	B40C, B41C
11	CTS	230	Q24HM, Q29HM
12	Dundas TS	115	B3, B4
13	Dundas TS #2	115	B12BL, B13BL
14	Elgin TS	115	HL3, HL4
15	Gage TS	115	B10, B11
16	Horning TS	230	M27B, M28B
17	CTS	230	N20K
18	Jarvis TS	230	N21J, N22J
19	Kenilworth TS	115	H5K, H6K
20	Lake TS	230	B18H, B20H
21	CTS	115	B3, B4
22	Mohawk TS	115	B3, B4
23	Nebo TS	230	Q24HM, Q29HM
24	Newton TS	115	Newton TS 115 kV Bus (2)
25	Norfolk TS	115	C9, C12
26	Powerline MTS	115	B12BL, B13BL
27	Stirton TS	115	HL3, HL4
28	CTS	230	N21J, N22J
29	Winona TS	115	Q2AH

(1) Beach TS 230 kV bus is supplied by five 230 kV B18H, B20H, Q24HM, Q29HM and M34H circuits

(2) Newton TS 115 kV bus is supplied by four 115 kV B3, B4, B12BL and B13BL circuits

APPENDIX C: DISTRIBUTORS IN THE BURLINGTON TO NANTICOKE REGION

Distributor Name	Station Name	Connection Type
Energy + Inc.	Brant TS	Dx, Tx
	Brantford TS	Dx
Brantford Power Inc.	Brant TS	Tx
	Brantford TS	Tx
Brantford Power Inc. and Energy + Inc.	Powerline MTS	Tx
Burlington Hydro Inc.	Bronte TS	Tx
	Burlington TS	Tx
	Cumberland TS	Tx
Haldimand County Hydro Inc.	Caledonia TS	Dx, Tx
	Jarvis TS	Dx, Tx
Alectra Utilities Corporation	Beach TS	Tx
	Birmingham TS	Tx
	Dundas TS	Dx, Tx
	Dundas TS #2	Tx
	Elgin TS	Tx
	Gage TS	Tx
	Horning TS	Tx
	Kenilworth TS	Tx
	Lake TS	Dx, Tx
	Mohawk TS	Tx
	Nebo TS	Dx, Tx
	Newton TS	Tx
	Stirton TS	Tx
	Winona TS	Tx
Hydro One Networks Inc.	Brant TS	Tx
	Caledonia TS	Tx
	Dundas TS	Tx
	Dundas TS #2	Tx
	Jarvis TS	Tx
	Lake TS	Tx
	Nebo TS	Tx
	Norfolk TS	Dx, Tx
	Bloomsburg DS	Dx, Tx
Oakville Hydro Electricity Distribution Inc.	Bronte TS	Tx

APPENDIX D: REGIONAL LOAD FORECASTS (MW)

Table – 1 Burlington to Nanticoke Region - Non-Coincident Load Forecast (Extreme Weather Corrected)

Area	Station	LTR	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Brant 115 kV	Brant TS (T1 / T2)	101	70	75	81	81	82	83	84	85	86	86	87	88	89	93	94	95	96	98	99	100	101	102
	Powerline MTS (T1 / T2)	114	78	78	82	83	85	86	87	88	89	90	92	93	94	96	97	99	100	103	104	106	108	110
	Total		**148**	**153**	**164**	**165**	**167**	**169**	**171**	**173**	**175**	**177**	**179**	**181**	**183**	**189**	**191**	**194**	**197**	**200**	**203**	**206**	**209**	**212**
Brant 230 kV	Brantford TS (T3 / T4)	188	141	164	166	170	172	175	177	179	180	187	189	191	194	196	198	199	202	205	208	210	213	215
	Total		**141**	**164**	**166**	**170**	**172**	**175**	**177**	**179**	**180**	**187**	**189**	**191**	**194**	**196**	**198**	**199**	**202**	**205**	**208**	**210**	**213**	**215**
Burlington and Oakville 115 kV	Bronte TS (T2 / T5 / T6)	180	141	133	134	136	137	138	139	140	141	143	144	143	143	143	143	143	143	143	143	143	143	143
	Total		**141**	**133**	**134**	**136**	**137**	**138**	**139**	**140**	**141**	**143**	**144**	**143**	**143**	**143**	**143**	**143**	**143**	**143**	**143**	**143**	**143**	**143**
Burlington and Oakville 230 kV	Burlington TS (T15 / T16)	185	141	154	154	154	153	153	153	152	152	151	151	151	151	150	150	150	150	150	150	150	150	150
	Cumberland TS (T3 / T4)	174	120	123	124	125	126	127	128	129	130	131	132	133	135	136	137	137	137	137	137	137	137	137
	Total		**260**	**277**	**278**	**279**	**279**	**280**	**280**	**281**	**282**	**282**	**283**	**284**	**285**	**287**	**287**	**286**	**287**	**287**	**287**	**287**	**287**	**287**
Greater Hamilton 115 kV	Birmingham TS (T1 / T2)	76	21	29	33	33	33	33	33	32	32	32	32	32	32	31	31	31	31	31	31	31	31	31
	Birmingham TS (T3 / T4)	91	59	60	63	63	62	62	62	61	61	61	61	60	60	60	59	59	59	59	59	59	58	58
	Dundas TS (T1 / T2)	99	100	106	111	112	113	114	114	115	116	116	117	118	119	119	120	121	122	131	132	133	134	135
	Dundas TS #2 (T5 / T6)	89	50	53	54	56	57	57	57	56	56	56	55	55	55	55	55	55	54	54	54	54	54	54
	Elgin TS (T1 / T2)	135	98	105	111	114	118	118	117	116	116	115	115	114	114	113	113	112	114	113	113	113	113	113
	Gage TS (T3 / T4)	57	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	20	19	19	19	19
	Gage TS (T5 / T6)	57	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Gage TS (T8 / T9)	123	16	16	16	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	14	14	14
	Kenilworth TS (T2 / T3)	127	52	52	52	52	52	51	51	51	50	50	50	50	50	49	49	49	49	49	48	48	48	48
	Mohawk TS (T1 / T2)	104	75	77	77	77	77	77	76	76	76	75	75	75	74	74	73	73	73	73	73	73	73	72
	Newton TS (T1 / T2)	78	52	53	54	60	62	62	62	61	61	61	60	60	60	60	60	59	59	59	59	59	59	59
	Stirton TS (T3 / T4)	112	44	46	48	50	53	53	52	52	52	52	51	51	51	51	51	50	50	50	50	50	50	50
	Winona TS (T1 / T2)	89	49	52	52	56	58	58	57	57	57	56	56	56	56	56	56	55	55	55	55	55	55	55
	Total CTS		24	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
	Total		**675**	**706**	**729**	**747**	**761**	**759**	**756**	**753**	**750**	**747**	**745**	**743**	**742**	**741**	**738**	**736**	**737**	**746**	**746**	**745**	**745**	**745**
Greater Hamilton 230 kV	Beach TS (T3/T4)	135	24	36	36	36	36	35	35	35	35	35	35	34	34	34	34	34	34	34	34	33	33	33
	Beach TS (T5 / T6)	96	57	64	65	65	66	65	67	66	66	66	65	65	65	65	64	64	64	64	64	64	64	63
	Horning TS (T3 / T4)	113	77	79	79	79	80	79	79	78	78	78	77	77	76	76	76	75	75	75	75	75	75	75
	Lake TS (T1 / T2)	94	50	51	51	58	58	57	57	57	56	56	56	56	55	56	55	55	55	55	55	55	55	54
	Lake TS (T3 / T4)	113	54	54	55	52	54	53	53	53	53	52	52	52	52	51	51	51	51	50	50	50	50	50
	Nebo TS (T1/T2)	178	127	127	135	140	144	148	151	154	157	160	166	168	170	172	174	176	179	181	184	186	188	191
	Nebo TS (T3 / T4)	51	52	53	53	53	53	53	53	52	52	52	52	51	51	51	51	51	51	51	51	50	50	50
	Total CTS		255	249	230	228	244	244	242	241	241	240	240	239	239	238	238	237	237	237	237	237	237	237
	Total		**695**	**714**	**703**	**711**	**735**	**736**	**737**	**737**	**738**	**739**	**742**	**742**	**742**	**743**	**743**	**743**	**744**	**747**	**749**	**750**	**753**	**754**
Caledonia Norfolk 115 kV	Norfolk TS (T1/T2)	97	57	61	67	68	69	69	74	74	74	78	82	84	85	86	87	87	87	88	88	89	89	90
	Bloomsburg DS (T1/T2)	49	38	40	41	44	52	61	69	69	69	69	69	69	73	74	74	74	74	76	76	76	76	77
	Total		**95**	**101**	**108**	**112**	**120**	**130**	**143**	**143**	**143**	**147**	**151**	**153**	**158**	**160**	**161**	**161**	**162**	**164**	**165**	**165**	**166**	**166**
Caledonia Norfolk 230 kV	Caledonia TS (T1/T2)	99	41	43	52	62	67	69	70	72	74	75	85	85	86	87	88	88	89	90	91	92	93	94
	Jarvis TS (T3/T4)	100	67	74	76	78	79	79	80	80	81	81	82	82	83	84	84	85	86	87	87	88	89	89
	Total CTS		117	115	116	118	117	117	117	116	116	116	115	115	115	115	114	114	114	114	114	114	114	114
	Total		**225**	**232**	**245**	**257**	**263**	**265**	**267**	**268**	**270**	**272**	**282**	**283**	**284**	**285**	**286**	**287**	**290**	**291**	**293**	**294**	**296**	**297**
Regional Total			2381	2480	2527	2577	2633	2652	2669	2673	2680	2694	2715	2720	2732	2744	2748	2751	2761	2782	2793	2801	2812	2820

Table – 2 Burlington to Nanticoke Region - Coincident Load Forecast (Extreme Weather Corrected)

Area	Station	LTR	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Brant 115 kV	Brant TS (T1 / T2)	101	50	54	58	58	59	60	60	61	61	62	63	63	64	68	69	69	70	71	72	73	74	75
	Powerline MTS (T1 / T2)	114	64	64	67	68	69	70	71	72	73	74	75	76	77	79	80	81	82	84	86	87	89	90
	Total		**114**	**118**	**126**	**127**	**128**	**130**	**131**	**133**	**134**	**136**	**138**	**139**	**141**	**146**	**148**	**150**	**153**	**155**	**158**	**160**	**162**	**165**
Brant 230 kV	Brantford TS (T3 / T4)	188	132	153	155	159	161	164	166	167	169	176	177	179	182	184	186	187	190	192	195	197	199	202
	Total		**132**	**153**	**155**	**159**	**161**	**164**	**166**	**167**	**169**	**176**	**177**	**179**	**182**	**184**	**186**	**187**	**190**	**192**	**195**	**197**	**199**	**202**
Burlington and Oakville 115 Kv	Bronte TS (T2 / T5 / T6)	180	106	105	106	107	108	109	109	110	111	112	113	113	113	113	113	112	112	113	113	113	113	113
	Total		**106**	**105**	**106**	**107**	**108**	**109**	**109**	**110**	**111**	**112**	**113**	**113**	**113**	**113**	**113**	**112**	**112**	**113**	**113**	**113**	**113**	**113**
Burlington and Oakville 230 kV	Burlington TS (T15 / T16)	185	133	146	146	145	145	145	144	144	143	143	143	142	142	142	142	142	141	142	142	142	142	142
	Cumberland TS (T3 / T4)	174	106	109	110	111	111	112	113	114	115	116	117	118	119	121	121	121	121	121	121	121	122	122
	Total		**239**	**254**	**255**	**256**	**257**	**257**	**257**	**258**	**258**	**259**	**259**	**260**	**262**	**263**	**263**	**263**	**263**	**263**	**263**	**263**	**263**	**263**
Greater Hamilton 115 kV	Birmingham TS (T1 / T2)	76	13	13	15	15	15	15	15	15	15	15	15	15	15	14	14	14	14	14	14	14	14	14
	Birmingham TS (T3 / T4)	91	48	49	51	51	51	51	50	50	50	49	49	49	49	49	48	48	48	48	48	48	48	47
	Dundas TS (T1 / T2)	99	79	84	88	89	89	90	91	91	92	92	93	93	94	95	95	96	96	106	107	107	108	109
	Dundas TS #2 (T5 / T6)	89	43	46	48	49	50	50	49	49	49	49	48	48	48	48	48	48	48	48	48	48	47	47
	Elgin TS (T1 / T2)	135	77	82	87	89	93	93	92	91	91	91	90	90	89	89	89	88	90	90	89	89	89	89
	Gage TS (T3 / T4)	57	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Gage TS (T5 / T6)	57	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7
	Gage TS (T8 / T9)	123	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Kenilworth TS (T2 / T3)	127	48	48	48	48	48	47	47	47	47	46	46	46	46	45	45	45	45	45	45	45	44	44
	Mohawk TS (T1 / T2)	104	61	62	62	63	63	62	62	62	61	61	61	60	60	60	60	59	59	59	59	59	59	59
	Newton TS (T1 / T2)	78	49	50	50	56	58	58	58	57	57	57	56	56	56	56	56	55	55	55	55	55	55	55
	Stirton TS (T3 / T4)	112	42	43	45	47	50	50	50	49	49	49	49	49	48	48	48	48	48	47	47	47	47	47
	Winona TS (T1 / T2)	89	47	50	51	55	56	56	55	55	55	55	54	54	54	54	54	54	53	53	53	53	53	53
	Total CTS	50	14	16	16	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	16	16	16
	Total		**549**	**569**	**587**	**603**	**615**	**613**	**611**	**608**	**607**	**604**	**603**	**601**	**600**	**599**	**597**	**596**	**596**	**605**	**605**	**605**	**605**	**604**
Greater Hamilton 230 kV	Beach TS (T3/T4)	135	16	16	16	16	16	16	16	16	16	16	15	15	15	15	15	15	15	15	15	15	15	15
	Beach TS (T5 / T6)	96	53	59	60	60	61	61	62	62	61	61	61	61	60	60	60	60	59	59	59	59	59	59
	Horning TS (T3 / T4)	113	63	64	65	65	65	65	64	64	64	63	63	63	62	62	62	62	61	62	61	61	61	61
	Lake TS (T1 / T2)	94	50	51	51	58	58	58	58	57	57	57	56	56	56	56	56	56	55	55	55	55	55	55
	Lake TS (T3 / T4)	113	50	51	51	48	50	50	50	49	49	49	49	48	48	48	48	48	47	47	47	47	47	47
	Nebo TS (T1/T2)	178	120	120	126	132	136	139	142	145	148	151	156	158	160	162	164	166	168	170	173	175	177	179
	Nebo TS (T3 / T4)	51	38	39	39	39	39	39	39	38	38	38	38	38	37	37	37	37	37	37	37	37	37	37
	Total CTS	305	185	189	172	171	185	185	184	183	183	182	182	181	181	181	180	180	180	180	180	180	180	180
	Total		**574**	**589**	**581**	**589**	**610**	**612**	**613**	**614**	**615**	**616**	**620**	**620**	**621**	**622**	**622**	**622**	**623**	**626**	**628**	**629**	**631**	**633**
Caledonia Norfolk 115 kV	Norfolk TS (T1/T2)	97	33	35	39	39	39	39	42	42	43	46	50	52	52	54	54	55	55	55	55	56	56	56
	Bloomsburg DS (T1/T2)	49	26	27	28	30	35	41	46	46	46	47	47	47	51	51	51	51	51	53	53	53	53	53
	Total		**58**	**62**	**66**	**69**	**74**	**80**	**89**	**89**	**89**	**93**	**97**	**98**	**103**	**105**	**105**	**106**	**106**	**108**	**108**	**109**	**109**	**109**
Caledonia Norfolk 230 kV	Caledonia TS (T1/T2)	99	20	21	26	31	33	34	35	36	37	37	46	46	47	47	48	48	49	49	49	50	50	51
	Jarvis TS (T3/T4)	100	53	59	60	61	62	63	63	64	64	64	65	65	66	67	67	67	69	69	70	70	70	71
	Total CTS	225	92	97	97	99	98	98	98	98	97	97	97	97	96	96	96	96	96	96	96	96	96	96
	Total		**166**	**177**	**184**	**191**	**194**	**195**	**196**	**197**	**198**	**199**	**208**	**208**	**209**	**210**	**210**	**211**	**213**	**214**	**215**	**216**	**217**	**218**
Regional Total			**1937**	**2027**	**2060**	**2101**	**2147**	**2160**	**2173**	**2176**	**2182**	**2194**	**2214**	**2219**	**2229**	**2241**	**2245**	**2247**	**2256**	**2276**	**2285**	**2291**	**2300**	**2307**

APPENDIX E: LIST OF ACRONYMS

Acronym	Description
A	Ampere
BES	Bulk Electric System
BPS	Bulk Power System
CDM	Conservation and Demand Management
CIA	Customer Impact Assessment
CGS	Customer Generating Station
CSS	Customer Switching Station
CTS	Customer Transformer Station
DCF	Discounted Cash Flow
DESN	Dual Element Spot Network
DG	Distributed Generation
DSC	Distribution System Code
GATR	Guelph Area Transmission Reinforcement
GS	Generating Station
GTA	Greater Toronto Area
HV	High Voltage
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kV	Kilovolt
LDC	Local Distribution Company
LP	Local Plan
LTE	Long Term Emergency
LTR	Limited Time Rating
LV	Low Voltage
MTS	Municipal Transformer Station
MW	Megawatt
MVA	Mega Volt-Ampere
MVAR	Mega Volt-Ampere Reactive
NA	Needs Assessment
NERC	North American Electric Reliability Corporation
NGS	Nuclear Generating Station
NPCC	Northeast Power Coordinating Council Inc.
NUG	Non-Utility Generator
OEB	Ontario Energy Board
OPA	Ontario Power Authority
ORTAC	Ontario Resource and Transmission Assessment Criteria
PF	Power Factor
PPWG	Planning Process Working Group
RIP	Regional Infrastructure Plan
ROW	Right-of-Way
SA	Scoping Assessment
SIA	System Impact Assessment
SPS	Special Protection Scheme
SS	Switching Station
TS	Transformer Station
TSC	Transmission System Code
UFLS	Under Frequency Load Shedding
ULTC	Under Load Tap Changer
UVLS	Under Voltage Load Rejection Scheme