London Area

REGIONAL INFRASTRUCTURE PLAN

August 25th, 2017

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Prepared by:
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With support from:

Organizations
Independent Electricity System Operator
Entegrus Inc.
Erie Thames Power Lines Corporation
London Hydro Inc.
St. Thomas Energy Inc.
Tillsonburg Hydro Inc.
Hydro One Networks Inc. (Distribution)

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 identified in previous planning phases and also any additional needs identified based on new and/or updated information provided by the RIP Working Group.

The preferred solution(s) that have been identified in this report may be re-evaluated 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 Working Group.

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EXECUTIVE SUMMARY

THIS REGIONAL INFRASTRUCTURE PLAN ("RIP") WAS PREPARED BY HYDRO ONE NETWORKS INC. ("HYDRO ONE") AND THE WORKING GROUP IN ACCORDANCE WITH THE ONTARIO TRANSMISSION SYSTEM CODE REQUIREMENTS. IT IDENTIFIES INVESTMENTS IN TRANSMISSION FACILITIES, DISTRIBUTION FACILITIES, OR BOTH, THAT SHOULD BE DEVELOPED AND IMPLEMENTED TO MEET THE ELECTRICITY INFRASTRUCTURE NEEDS OF THE LONDON AREA REGION.

The participants of the RIP Working Group included members from the following organizations:

- Hydro One Networks Inc. (Distribution)
- Independent Electricity System Operator
- Entegrus Inc.
- Erie Thames Power Lines Corporation
- London Hydro Inc.
- St. Thomas Energy Inc.
- Tillsonburg Hydro Inc.
- Hydro One Networks Inc. (Transmission)

This RIP is the final phase of the OEB's mandated regional planning process for the London Area Region which consists of the Strathroy Sub-Region, Greater London Sub-Region, Woodstock Sub-Region, Aylmer-Tillsonburg Sub-Region, and the St. Thomas Sub-Region. It follows the completion of the London Area Region's Needs Assessment ("NA") in April 2015, the London Area Region Scoping Assessment ("SA") in August 2015, the Strathroy TS Transformer Capacity Local Plan ("LP") in September 2016, the Greater London Sub-Region Integrated Regional Resource Plan ("IRRP") in January 2017, and the Woodstock Sub-Region Restoration Local Plan ("LP") in May 2017.

This RIP provides a consolidated summary of needs and recommended plans for the entire London Area Region. Needs which are to be addressed include:

- Load restoration in Woodstock Sub-Region
- Load restoration in Greater London Sub-Region
- Voltage constraints, thermal constrains and delivery point performance in Aylmer-Tillsonburg Sub-Region

The major infrastructure investments planned for the region over the near and mid-term, as identified in the regional planning process are given below.

No.	Project	I/S Date	Estimated Cost[1]
1	Distribution System Upgrades in the Greater London Sub-Region	2023	$1.8-4M ($180/kW)
2	Wonderland TS Reinvestment: Replace transformer T5	2022	$15-20M

As per the Regional Planning process, the Regional Plan will be reviewed and/or updated at least once every five years. Should there be a need that emerges due to a change in load forecast or any other reason, the next regional planning cycle will be started earlier to address the need.

[1] Costs presented are preliminary estimate and may change resulting from clarification of scope and through detailed cost estimating.

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1. INTRODUCTION

THIS REPORT PRESENTS THE REGIONAL INFRASTRUCTURE PLAN (“RIP”) TO ADDRESS THE ELECTRICITY NEEDS OF THE LONDON AREA REGION.

The report was prepared by Hydro One Networks Inc. (“Hydro One”) and documents the results of the study with input and consultation with Independent Electricity System Operator, Entegrus Inc., Erie Thames Power Lines Corporation, London Hydro Inc., St. Thomas Energy Inc., Tillsonburg Hydro Inc., and Hydro One Networks Inc. (Distribution) in accordance with the Regional Planning process established by the Ontario Energy Board (“OEB”) in 2013.

The London Area is located in South Western Ontario and includes all or part of the following Counties, and Cities: Oxford County, Middlesex County, Elgin County, Norfolk County, the City of Woodstock, the City of London, and the City of St. Thomas. For electricity planning purposes, the planning region is defined by electricity infrastructure boundaries, not municipal boundaries.

The region also includes the following First Nations: Chippewas of the Thames, Oneida Nation of the Thames, and Munsee-Delaware Nation.

Electrical supply to the London Area is provided through a network of 230 kV and 115 kV circuits supplied by 500/230 kV autotransformers at Longwood Transformer Station (TS) and 230/115 kV autotransformers at Buchanan TS and Karn TS. There are fifteen Hydro One step-down TS’s, four direct transmission connected load customers and three transmission connected generators in the London Area. The distribution system consists of voltage levels 27.6 kV and 4.16kV.The boundaries of the Region are shown in Figure 1-1 below.

Within the current regional planning cycle, four regional assessments have been conducted for the London Area Region. The findings of these studies are an input to the RIP and the studies are as follows:

1. IESO’s Greater London Sub-Region Integrated Regional Resource Plan – January, 2017
2. Hydro One’s Woodstock Sub-Region Restoration Local Plan - May, 2017
3. Hydro One’s Strathroy TS Transformer Capacity Local Plan – September, 2016
4. Hydro One’s London Area Region Needs Assessment Report – April, 2015

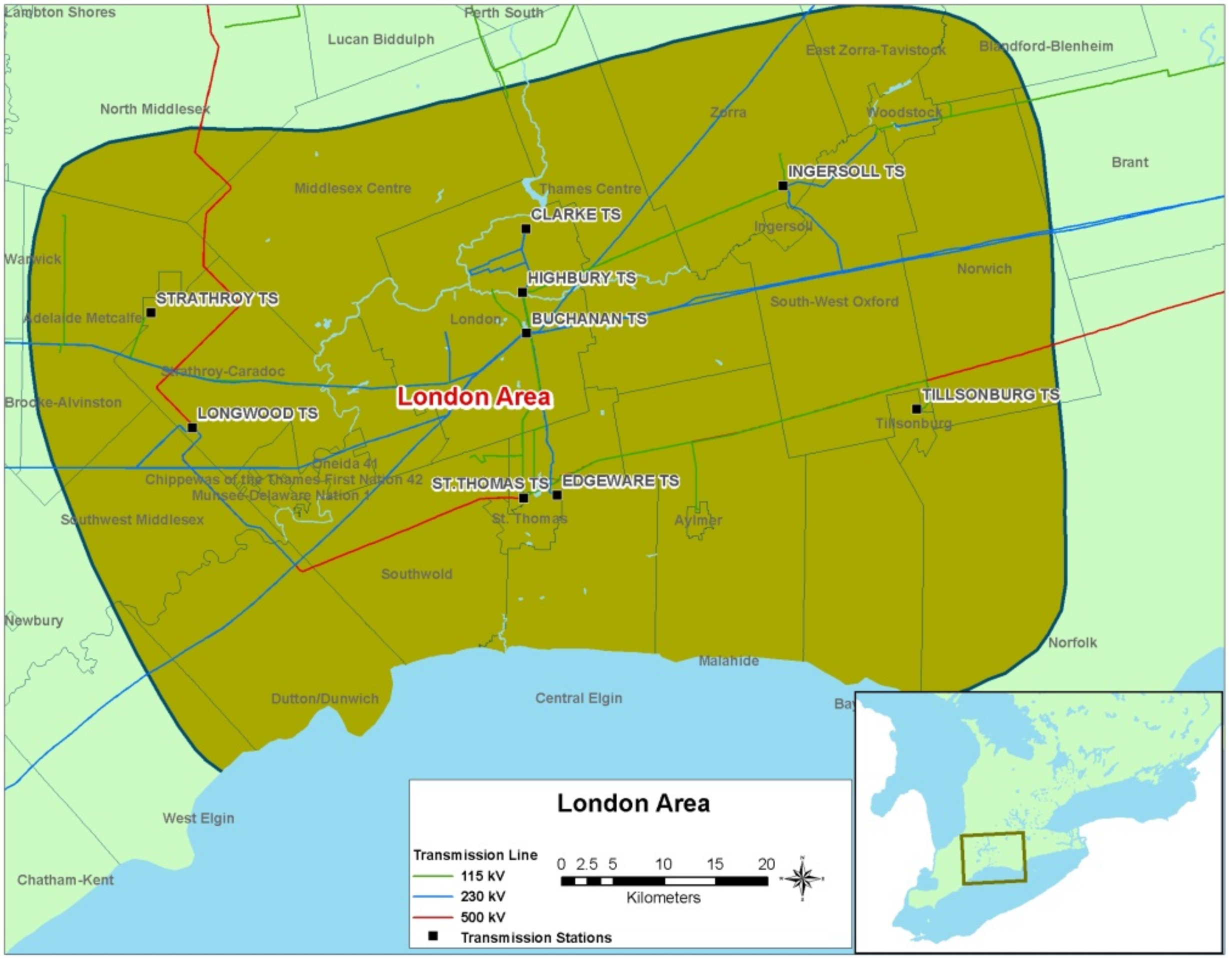


Figure 1-1 London Area Region

1.1 Scope and Objectives

This RIP report examines the needs in the London Area Region and its objectives are to:

- Confirm supply needs identified in previous planning phases;
- Identify new supply needs that may have emerged since previous planning phases (e.g., Needs Assessment, Scoping Assessment, Local Plan, and/or Integrated Regional Resource Plan);
- Assess and develop wires plans to address these needs;
- Provide the status of wires planning currently underway or completed for specific needs;
- 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 reviews factors such as the load forecast, transmission and distribution system capability along with any updates with respect to local plans, conservation and demand management ("CDM"), 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 report of the needs and relevant plans to address near and mid-term needs (2016-2025) identified in previous planning phases (Needs Assessment, Scoping Assessment, Local Plan or Integrated Regional Resource Plan);
- Identification of any new needs over the 2016-2025 period and a wires plan to address them;
- Consideration of long-term needs identified in the Greater London Sub-Region IRRP

As per the Regional Planning process, the Regional Plan for the region will be reviewed and/or updated at least every five years. Should there be a need that emerges due to a change in load forecast or any other reason, the next regional planning cycle will be started earlier to address the need.

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 major High Voltage 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 the regional needs
- Section 7 describes 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 performed at essentially 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 evaluates supply and reliability issues at a regional or local area level. Therefore, it largely considers the 115kV and 230kV 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[2] ("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 Working Group determines whether further regional coordination is necessary to address them. If no further regional coordination is required, and needs are local in nature, an assessment is undertaken for any necessary investments directly by the LDCs (or customers) and the transmitter through a Local Plan ("LP"). These needs are local in nature and can be best addressed by a straight forward wires solution. The Working Group recommends a LP undertaking when needs are a) local in nature b) limited to investments in wires (transmission or distribution) solutions c) do not require upstream transmission investments d) do not require plan level stakeholder engagement and e) do not require other approvals such as Leave to Construct (S92) approval or Environmental Approval.

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. If there are needs that do not require regional coordination, the Working Group can recommend them to be undertaken as part of the LP approach discussed above. Otherwise, the approach is to complete either a RIP, which is led by the transmitter, or an IRRP, which is led by the IESO. If more than one sub-

[2] Also referred to as Needs Screening.

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 need are then further planned in greater detail by the IESO. The IRRP phase also includes IESO led stakeholder engagement with municipalities and establishes a Local Advisory Committee ("LAC") in the region or sub-region.

The RIP phase is the final stage of the regional planning process and involves: confirmation of previously identified needs; 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 of this stage is a comprehensive report of a wires plan for the region. Once completed, this report can be referenced in rate filing submissions or as part of LDC rate applications with a planning status letter provided by the transmitter. Reflecting the timelines provisions of the RIP, plan level stakeholder engagement is not undertaken at this stage. However, stakeholder engagement at a project specific level will be conducted as part of the project approval requirement.

To efficiently manage the regional planning process, Hydro One has been undertaking wires planning activities in collaboration with the IESO and 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.

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.

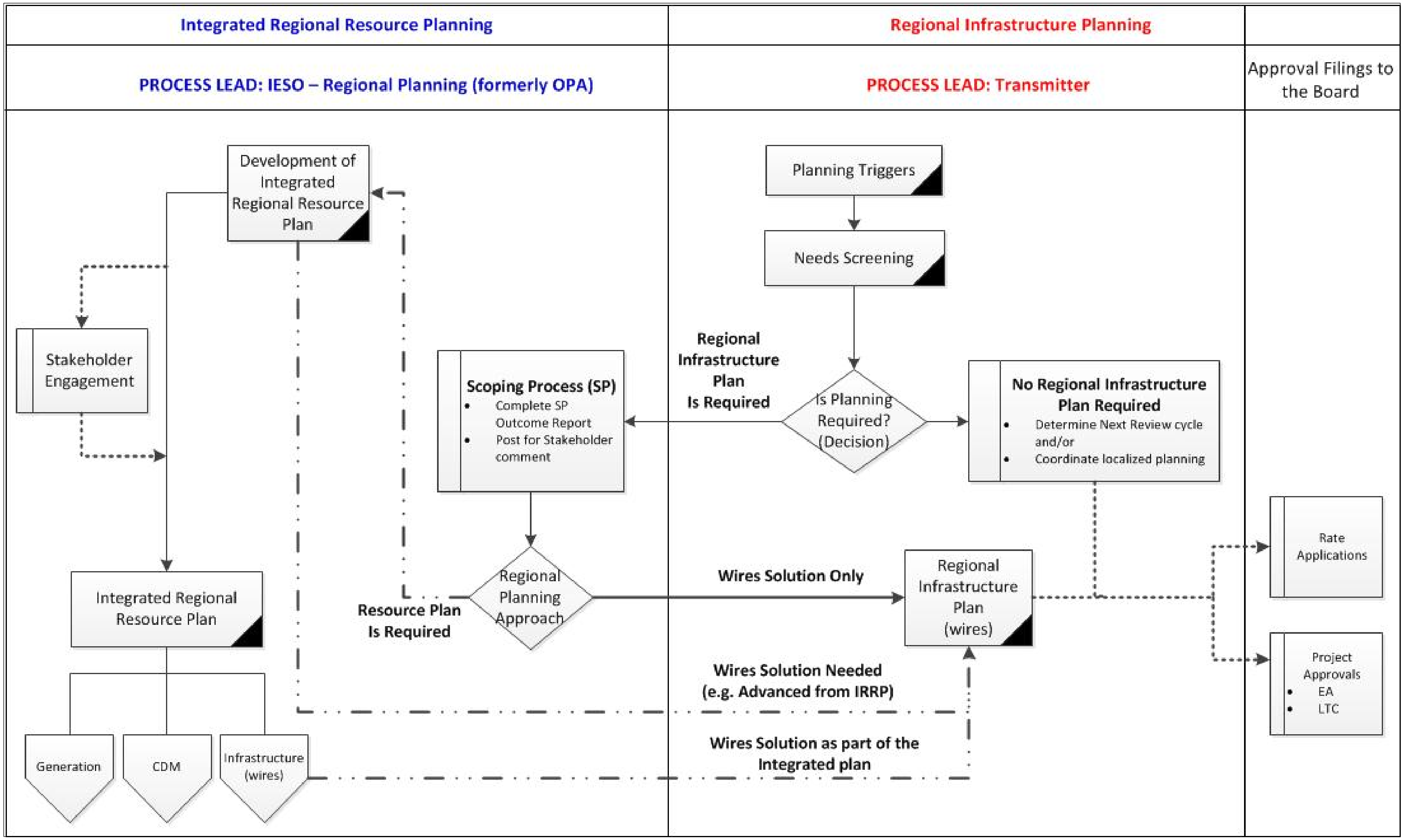


Figure 2-1 Regional Planning Process Flowchart

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 stages of the regional planning process. Hydro One collects the following information and reviews it with the Working Group to reconfirm or update the information as required:

    - Net peak demand forecast at the transformer station level. This includes the effect of any distributed generation ("DG") or CDM 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. Additional near and mid-term needs may be identified at this stage.

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.

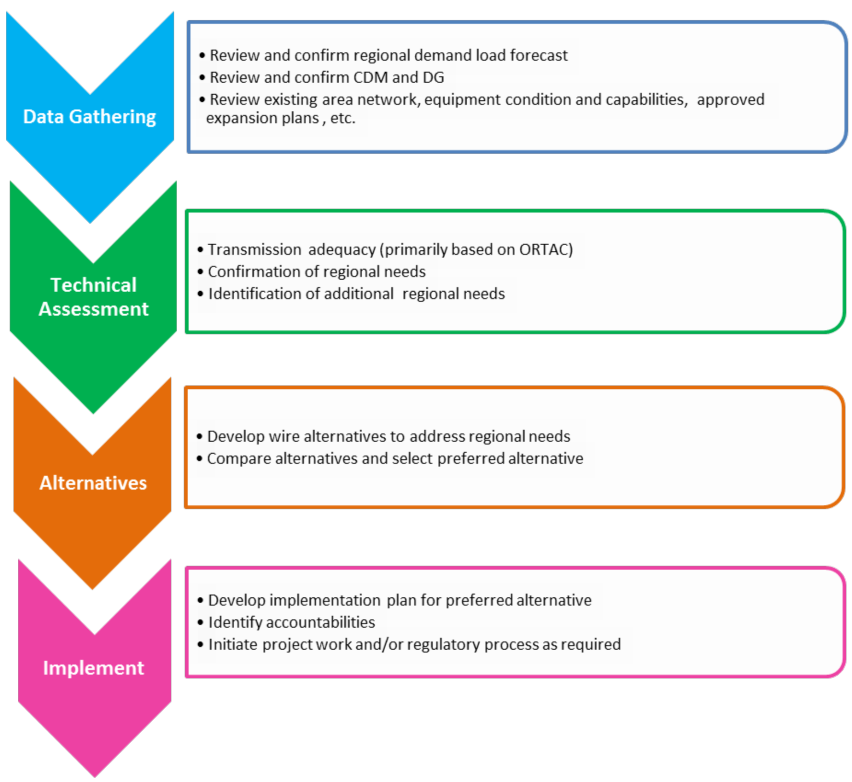


Figure 2-2 RIP Methodology

3. REGIONAL CHARACTERISTICS

THE LONDON AREA IS LOCATED IN SOUTH WESTERN ONTARIO AND INCLUDES ALL OR PART OF OXFORD COUNTY, MIDDLESEX COUNTY, ELGIN COUNTY, NORFOLK COUNTY, THE CITY OF WOODSTOCK, THE CITY OF LONDON, AND THE CITY OF ST. THOMAS. THE REGION ALSO INCLUDES THE FOLLOWING FIRST NATIONS: CHIPPEWAS OF THE THAMES, ONEIDA NATION OF THE THAMES, AND MUNSEE-DELAWARE NATION. LONDON AREA REGION IS DIVIDED INTO FIVE SUB-REGIONS: STATHROY SUB-REGION, GREATER LONDON SUB-REGION, WOODSTOCK SUB-REGION, AYLMER-TILLSONBURG SUB-REGION, AND THE ST. THOMAS SUB-REGION.

Electrical supply to the London Area Region is provided through a network of 230 kV and 115 kV circuits supplied by 500/230 kV autotransformers at Longwood Transformer Station (TS) and 230/115 kV autotransformers at Buchanan TS and Karn TS. There are fifteen Hydro One step-down TS', four direct transmission connected load customers and three transmission connected generators. The region is summer-peaking and has a peak demand of approximately 1,250 MW including direct transmission connected customers. A map of the London Area Region (highlighting the sub-regions) and a single line diagram of the transmission system are shown in Figure 3-1 and Figure 3.2.

Table 3-1 Sub-Region Details

Sub-Region	Station Name (DESN)	Voltage Level (kV)	Supply Circuits	Connected Customers
Strathroy Sub-Region	Strathroy TS (T7/T8)	230/27.6	W2S, S2N	• Hydro One Distribution • Entegrus
	Longwood TS (T13/T14)	230/27.6	L24L, L26L	• Hydro One Distribution
Greater London Sub-Region	Talbot TS (T1/T2, T3/T4)	230/27.6	W36, W37	• London Hydro • Hydro One Distribution
	Clark TS (T3/T4)	230/27.6	W36, W37	
	Wonderland TS (T5/T6)	230/27.6	N21W, N22W	
	Buchanan TS (T13/T14)	230/27.6	W42L, W43L	
	Nelson TS (T1/T2)	115/13.8	W5N, W6NL	
	Highbury TS (T3/T4)	115/27.6	W6NL, W9L	
Woodstock Sub-Region	Ingersoll TS (T5/T6)	230/27.6	M31W, M32W	• Hydro One Distribution • Erie Thames Powerlines
	Woodstock TS (T1/T2)	115/27.6	K7, K12	
	Commerceway TS (T1/T2)	115/27.6	K7, K12	
Aylmer Sub-Region	Aylmer TS (T2/T3)	115/27.6	WT1A, W8T, T11T	• Hydro One Distribution, • Erie Thames Powerlines • Tillsonburg Hydro
	Tillsonburg TS (T1/T3)	115/27.6	WT1T, W8T, T11T	
St.Thomas Sub-Region	St. Thomas TS	115/27.6kV	W3T, W4T, T11T	Station is planned for decommissioning, no remaining customers connected.
	Edgeware TS	230/27.6kV	W45LS, W44LC	• Hydro One Distribution • St. Thomas Energy • London Hydro

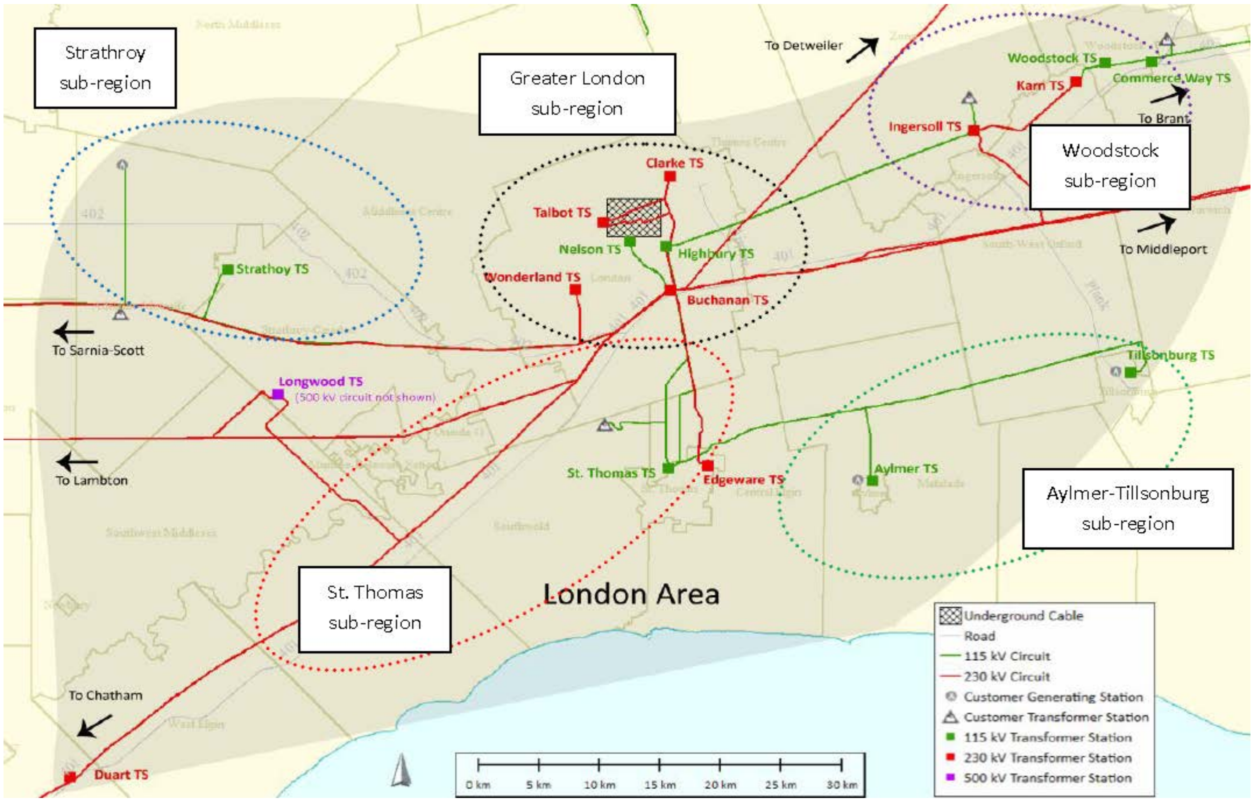
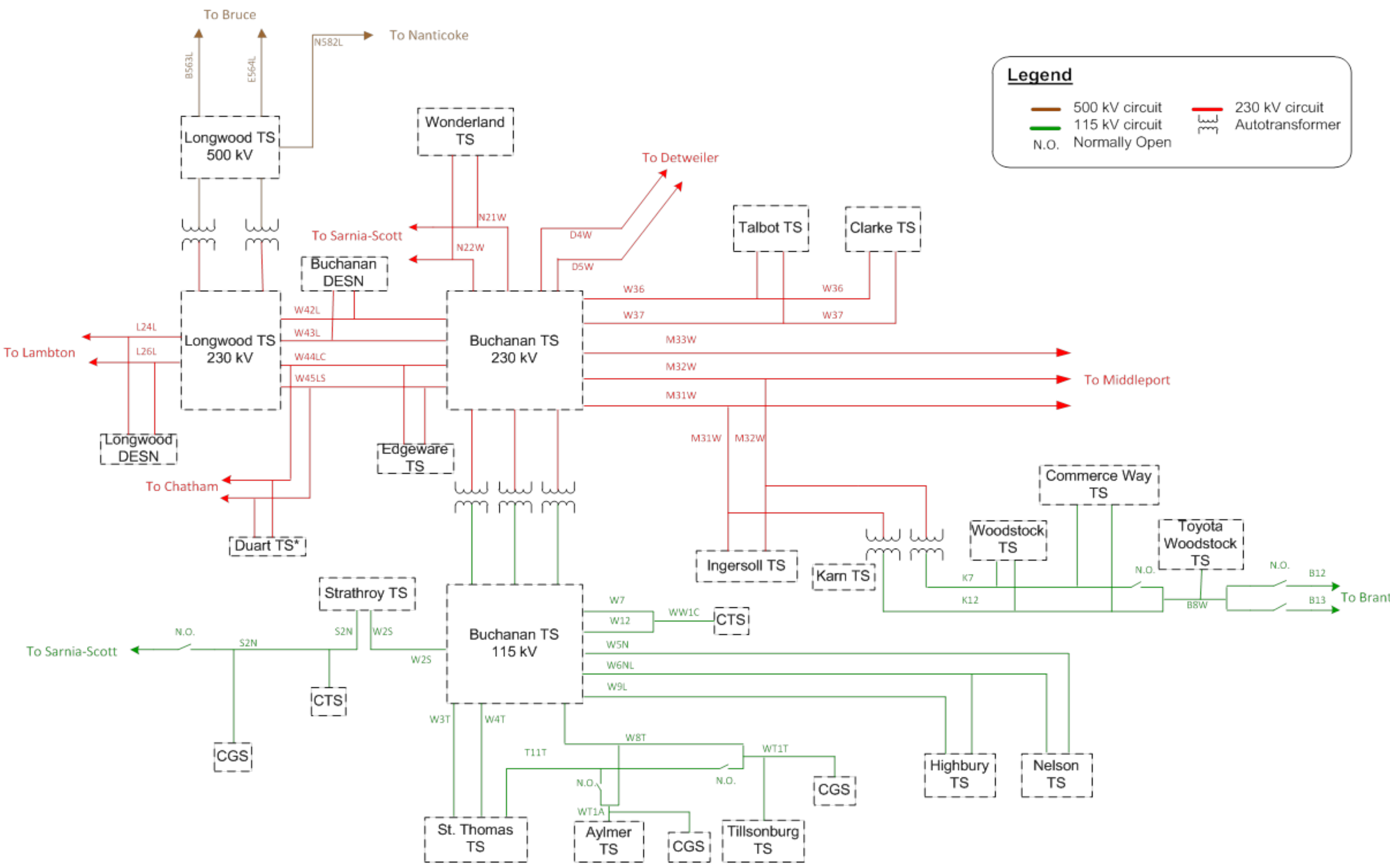


Figure 3-1 London Area Region – Supply Areas



* Part of Chatham-Kent/Sarnia/Lambtion Regional Planning, shown here for completeness

Figure 3-2 London Area Region Single Line Diagram

4. TRANSMISSION PROJECTS COMPLETED OR CURRENTLY UNDERWAY

OVER THE LAST 10 YEARS A NUMBER OF TRANSMISSION PROJECTS HAVE BEEN PLANNED AND COMPLETED BY HYDRO ONE, OR ARE UNDERWAY, AIMED AT IMPROVING THE SUPPLY TO THE LONDON AREA REGION.

A brief listing of the major projects completed over the last 10 years is given below:

- Talbot TS Expansion (2007) – Expansion of the existing Talbot TS and construction of a second 50/83 MVA 230/27.6 kV transformer station to alleviate load from existing transformer stations in the area, which were loaded beyond its capacity and provide additional capacity for the load growth in the London area.
- Highbury TS Transformer Replacement (2009) – Like-for-like replacement of 50/83 MVA 115/27.6 kV transformer T4 that was over 60 years old and nearing end-of-life.
- Commerce Way TS (2010) – Construction of a new 50/83 MVA 115/27.6 kV Commerce Way transformer station to alleviate load from Woodstock TS, which was loaded beyond its capacity and provide additional capacity for the load growth in the Woodstock area.
- Strathroy TS Transformer Replacement (2012) – Like-for-like replacement of 25/42 MVA 115/27.6 kV transformer T2 due to failure.
- Ingersoll TS Transformer Replacement (2012) – Like-for-like replacement of 75/125 MVA 230/27.6 kV transformers T5 & T6 that were approximately 35 years old. The transformers were identified to have a design weakness and were replaced to mitigate the risk of failures, improve restoration time and maintain system performance.
- Woodstock TS Transformer Replacement (2014) – Like-for-like replacement of 50/83 MVA 115/27.6 kV transformers T1 & T2 that were approximately 50 years old and were nearing end-of-life.

The following development projects are expected to be placed in-service within the next 10 years:

1. **Aylmer TS**: is located in Southwestern Ontario and is comprised of two 11/15 MVA, 110-28 kV transformers (T2 & T3) and two 27.6 kV feeder breaker positions M1, M2. The station is supplied by a single 115kV line WT1A and it supplies Erie Thames Powerlines Corp. and Hydro One Distribution at 27.6 kV.

   The deteriorating asset condition of a significant portion of station equipment, including transformers (T2 & T3) and LV switchyard, qualifies it as a candidate for a complete station rebuild. To address the urgent need, the existing station will be replaced with a new DESN with two 25/33/42 MVA transformers. The replacement work also includes all 28kV LV switching facilities, the addition of two new feeder positions, and an upgrade to associated protection and control systems.

   This project is currently under execution and planned to be completed before end of 2017.

2. **Strathroy TS**: is located in Middlesex County in Southwestern Ontario and is comprised of two 25/33/42 MVA 110-28 kV transformers (T1 & T2) and four 27.6 kV feeder breaker positions. Strathroy TS supplies Entegrus Powerlines Inc. and Hydro One Distribution at 27.6 kV.

   Due to deteriorating asset condition, Hydro One has planned to replace the T1 transformer with similar type 42MVA transformer, replace all LV switching facilities, and upgrade associated protection and control facilities and AC/DC station ancillary infrastructure.

   This project is currently under execution and planned to be completed in 2017.

3. **Nelson TS**: is located in the City of London in Southwestern Ontario and is comprised of two DESN stations (the "T1/T2 DESN" and the "T3/T4 DESN") which are both supplied from the 115 kV circuits W5N and W6NL. The T1/T2 DESN consists of two 18/27/33 MVA, 115/ 13.8 kV transformers with two LV yards (outdoor and indoor), and the T3/T4 DESN consists of two 60/80/100 MVA, 115/ 13.8 kV transformers with two LV yards (both indoor). The T1/T2 DESN supplies about 17 MW of 13.8kV load in the London downtown area and the T3/T4 DESN supplies approximately 31 MW of 13.8 kV load, also in the London downtown area.

   The deteriorating asset condition of a significant portion of station equipment, including transformers (T1 & T2) and LV switchyard, qualifies it as a candidate for a complete station rebuild. In addition, London Hydro has requested that Hydro One rebuild the LV at 27.6kV rather than at 13.8kV so that the station can be integrated into London Hydro's 27.6kV distribution system to provide load support. As a result, Hydro one is building a new station within the existing Nelson TS yard. The new station will consist of two new 115/27.6 kV, 50/83 MVA DESNs and new LV switchyard with 8 feeder positions and 2 capacitor bank positions. All associated protection and control systems and station ancillary infrastructure will be upgraded. The work will also involve decommissioning of the existing DESN substation consisting of T1 and T2 transformers and the 13.8kV air insulated outdoor switchyard.

   This project is currently under execution and planned to be completed in 2018.

5. FORECAST AND STUDY ASSUMPTIONS

THE FORECASTS REFLECT THE EXPECTED PEAK DEMAND AT EACH STATION UNDER EXTREME WEATHER CONDITIONS, BASED ON FACTORS SUCH AS POPULATION, HOUSEHOLD AND ECONOMIC GROWTH, CONSISTENT WITH MUNICIPAL PLANNING ASSUMPTIONS.

5.1 Historical Demand

The London Area regional peak load has been relatively constant over the past 5 years (approximate decline of -0.4%).

5.2 Contribution of CDM and DG

In developing the planning forecast, the following process was used to assess the London Region:

- First, “gross demand” is established. Gross demand reflects the forecast developed and provided by the area LDCs and is influenced by a number of factors such as economic, household and population growth.
- Second, “net demand” is derived by reducing the gross demand by expected savings from improved building codes and equipment standards, customer response to time-of-use pricing, projected province-wide CDM programs, committed and forecast DG . This information is provided by the IESO.

5.3 Gross and Net Demand Forecast

Prior to the RIP’s kick-off, the Working Group was asked to confirm the load forecasts for all stations in the Region provided for previous assessments. The RIP’s load forecast was updated according the revised load forecasts provided by the LDCs.

The load in the London Area Region including CDM targets and DG contributions is expected to remain relatively constant over the study period (approximate growth rate of -0.3%). The growth rate varies across the region but an overall coincident net load forecast in the region is illustrated in Figure 5-1. The gross and net non-coincident and coincident load forecast, adjusted for extreme weather, CDM, and DG, for each station in the region are provided in Appendix B and C.

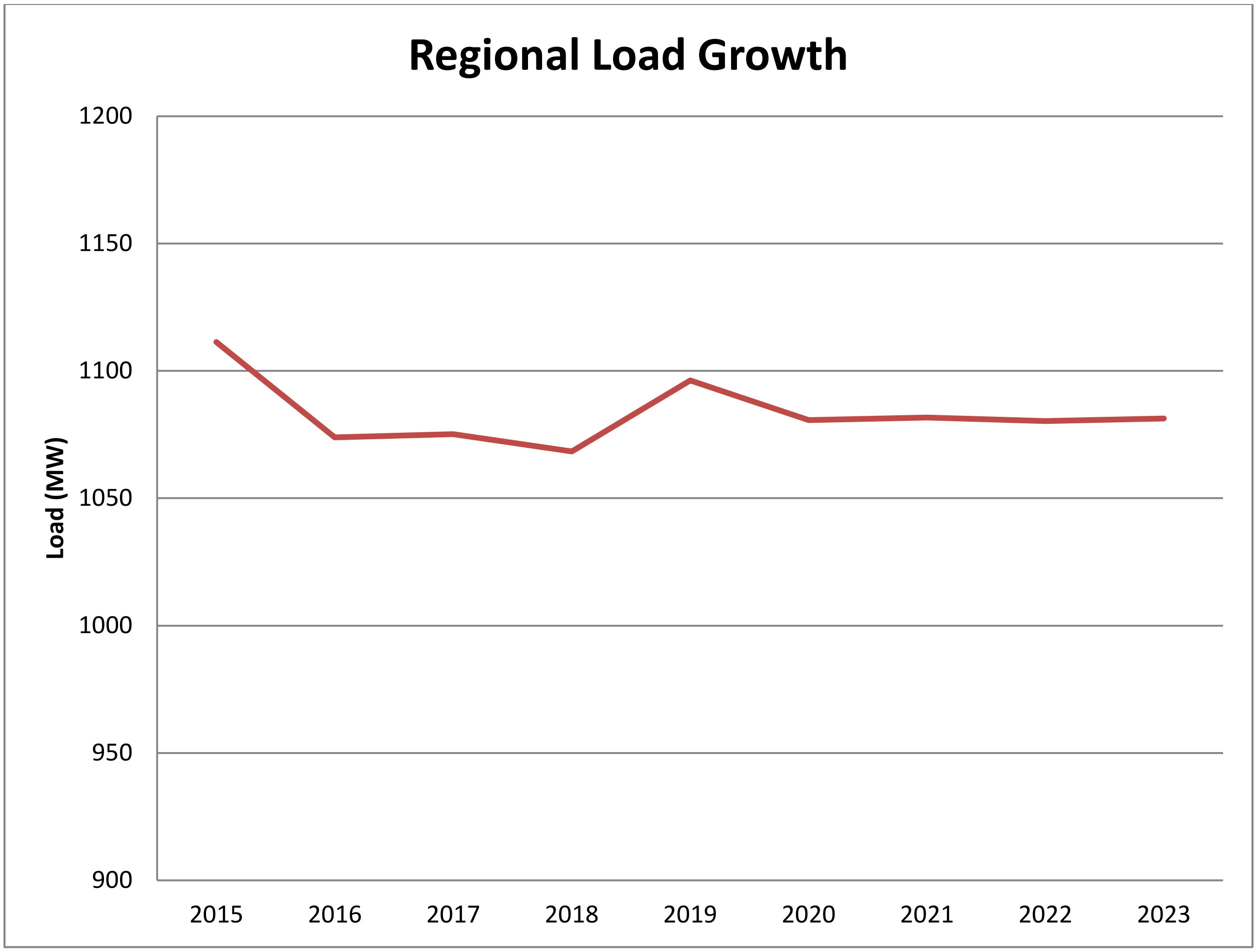


Figure 5-1 London Area Region Coincident Net Load Forecast

5.4 Other Study Assumptions

Further assumptions are as follows:

- The study period for the RIP assessment is 2016 – 2023.
- Summer is the critical period with respect to line and transformer loadings. The assessment is therefore based on extreme summer peak loads.
- Station capacity adequacy is assessed by comparing the 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. Normal planning supply capacity for transformer stations in this region is determined by the summer 10-Day Limited Time Rating ("LTR").

6. ADEQUACY OF FACILITIES

THIS SECTION REVIEWS THE ADEQUACY OF THE EXISTING TRANSMISSION AND STEP DOWN TRANSFORMATION STATION FACILITIES SUPPLYING THE LONDON AREA REGION AND LISTS THE FACILITIES REQUIRING REINFORCEMENT OVER THE NEAR AND MID-TERM PERIOD.

Within the current regional planning cycle, four regional assessments have been conducted for the London Area Region. The findings of these studies are an input to the RIP and the studies are as follows:

1. IESO's Greater London Sub-Region Integrated Regional Resource Plan – January, 2017[1]
2. Hydro One's Woodstock Sub-Region Restoration Local Plan - May, 2017[2]
3. Hydro One's Strathroy TS Transformer Capacity Local Plan – September, 2016[3]
4. Hydro One's London Area Region Needs Assessment Report – April, 2015[4]

The IRRP, NA, and LP studies identified a number of regional needs based on the forecast load demand over the near to mid-term. Based on the regional growth rate referred to in Section 5, this RIP reviewed the loading on transmission lines and stations in the London Area Region assuming the new Nelson TS DESN will be in-service by the end of 2018, and the new Aylmer TS DESN will be in-service by the end of 2017. Further detailed description and status of plans to meet these needs is provided in Section 7.

6.1 Transmission Line Facilities

Electrical supply to the London Area is provided through a network of 230 kV and 115 kV circuits supplied by 500/230 kV autotransformers at Longwood Transformer Station (TS) and 230/115 kV autotransformers at Buchanan TS and Karn TS. The main features of the electrical supply system in the London Area are as follows:

- Longwood TS is the major transmission station that connects the 500kV network to the 230kV system via two 500/230 kV autotransformers.
- Buchanan TS and Karn TS are the transmission stations that connect the 230kV network to the 115kV system via 230/115 kV autotransformers.
- Fifteen step-down transformer stations supply the London Area load: Aylmer TS, Buchanan TS, Clarke TS, Commerceway TS, Edgeware TS, Highbury TS, Ingersoll TS, Longwood TS, Nelson TS, Strathroy TS, St. Thomas TS, Talbot TS, Tillsonburg TS, Wonderland TS, and Woodstock TS.
- Four Customer Transformer Stations (CTS) are supplied in the London Area: Ford Talbotville CTS, Enbridge Keyser CTS, Lafarge Woodstock CTS, and Toyota Woodstock CTS.
- There are 3 existing transmission connected generating stations in the London Area as follows:

- Suncor Adelaide GS is a 40 MW wind farm connected to 115 kV circuit west of Strathroy TS
- Erie Shores Wind Farm GS is a 99 MW wind farm connected to 115kV circuit near Tillsonburg TS
- Silver Creek GS is a 10 MW solar generator connected to 115kV circuit near Aylmer TS

The 500kV system is part of the bulk system planning conducted by the IESO and is not studied as part of this RIP

Table 6-1 provides 230 kV and 115 kV circuit network that supplies to the London Area.

Table 6-1 230 kV and 115 kV circuits network in the London Area

Voltage	Circuit Designations	Location
230 kV	N21W, N22W	Scott TS to Buchanan TS
	W42L, W43L	Longwood TS to Buchanan TS
	W44LC	Longwood TS to Chatham TS to Buchanan TS
	W45LS	Longwood TS to Spence SS to Buchanan TS
	W36, W37	Buchanan TS to Talbot TS
	D4W, D5W	Buchanan TS to Detweiler TS
	M31W, M32W	Buchanan TS to Ingersoll TS to Middleport TS
	M33W	Buchanan TS to Brantford TS
115 kV	W2S	Buchanan TS to Strathroy TS
	W5N	Buchanan TS to Nelson TS
	W6NL	Buchanan TS to Highbury TS to Nelson TS
	W9L	Buchanan TS to Highbury TS
	W7, W12 WW1C W8T T11T WT1T W3T, W4T WT1A K7, K12	Buchanan TS to CTS Buchanan TS to CTS Buchanan TS to Cranberry JCT Erie Shore Wind Farm JCT to Tillsonburg TS Buchanan TS to St. Thomas TS Aylmer TS to Lyons JCT Karn TS to Commerce Way TS

The 115 kV circuit W8T from Buchanan TS to Edgeware JCT exceeds its planning rating under pre-contingency conditions in the near term based on the gross load forecast. Such thermal overload is deferred to the medium term based on the net load forecast. The transmission line constraint is further described in section 7.2.2 of this report. The remaining 115 kV and 230 kV circuits supplying the London Area are adequate over the study period for the loss of a single element in the area.

6.2 Step-Down Transformation Facilities

There are a total of fifteen step-down transmission connected transformer stations in the London Area Region. The stations have been grouped based on the geographical area and supply configuration. The station loading and the associated station capacity and the need date in each sub-region is provided in Table 6-3 below. The findings of the transformation capacity assessment are as follows:

- As confirmed in the "Strathroy TS Transformer Capacity Local Plan (LP)", based on the limited time rating ("LTR") of the station, the transformation capacity is adequate in Strathroy Sub-Region over the study period.
- As confirmed in the "Greater London Sub-Region Integrated Regional Resource Plan (IRRP)", based on the LTR of the stations, the transformation capacity is adequate in Greater London Sub-Region over the study period.
- Based on the LTR of the load stations, the transformation capacity is adequate in Woodstock Sub-Region, Aylmer-Tillsonburg Sub-Region and the St. Thomas Sub-Region over the study period.

Table 6-2 Transformation Capacities in the Sub-Regions

Sub-Region	Station	LTR (MW)	2015 Non Coincident Peak (MW)	Need Date
Strathroy Sub-Region	Strathroy TS	50	45	-[3]
	Longwood TS	128	33	-[3]
Greater London Sub-Region	Talbot TS	290	268	-[3]
	Clark TS	110	106	-[3]
	Wonderland TS	99	109[4]	-[3]
	Buchanan TS	183	143	-[3]
	Nelson TS	105[5]	23	-[3]
	Highbury TS	114	93	-[3]
Woodstock Sub-Region	Ingersoll TS	167	75	-[3]
	Woodstock TS	87	56	-[3]
	Commerceway TS	112	33	-[3]
Aylmer Sub-Region	Aylmer TS	55[6]	21	-[3]
	Tillsonburg TS	109	88	-[3]
St.Thomas Sub-Region	St.Thomas TS	50	0	-[3]
	Edgeware TS	191	113	-[3]

[3] Adequate over the study period

[4] Peak loading at Wonderland TS is forecasted to reduce to within its 10-day LTR rating by 2017

[5] Nelson TS LTR reflects the Station Rebuild Project under execution - planned to be completed in 2018

[6] Aylmer TS LTR reflects the Transformer Replacement Project under execution - planned to be completed in 2017

The non-coincident and coincident load forecast for all stations in the Region is given in Appendix C and Appendix D, respectively.

6.3 System Reliability and Load Restoration

In case of incidents 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.

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

In the London Area Region it is expected that all loads can be restored within the ORTAC load restoration requirements with exception of:

- Loss of M31W/M32W – Woodstock Sub-Region
- Loss of W36/W37 or W42L/W43L – Greater London Sub-Region

The load restoration constraints are further described in section 7.1 of this report.

6.4 Voltage

Under pre-contingency conditions with all facilities in service, ORTAC provides requirements for acceptable system voltages. The table below indicates the maximum and minimum voltages generally applicable. These values are obtained from Chapter 4 of the IESO "Market Rules" and CSA standards for distribution voltages below 50 kV.

Table 6-3 Pre-Contingency Voltage Limits

Nominal Bus Voltage (kV)	500	230	115	Transformer Station Low Voltage Bus
Maximum Continuous (kV)	550	250	127*	106%
Minimum Continuous (kV)	490	220	113	98%

*Certain buses can be assigned specific maximum and minimum voltages as required for operations. In northern Ontario, the maximum continuous voltage for the 115 kV system can be as high as 132 kV.

With all planned facilities in service pre-contingency, ORTAC provides requirements for system voltage changes in the period immediately following a contingency as indicated in Table 6-4.

Table 6-4 Post-Contingency Voltage Change Limits

Nominal Bus Voltage (kV)	500	230	115	Transformer Station Low Voltage Bus		
				44	27.6	13.8
% voltage change **before** tap changer action	10%	10%	10%	10%		
% voltage change **after** tap changer action	10%	10%	10%	5%		
AND within the range						
Maximum* (kV)	550	250	127	112% of nominal		
Minimum* (kV)	470	207	108	88% of nominal		

*The maximum and minimum voltage ranges are applicable following a contingency. After the system is re-dispatched and generation and power flows are adjusted the system must return to within the maximum and minimum continuous voltages.

The Aylmer-Tillsonburg Sub-Region is normally supplied by a single 115 kV transmission circuit W8T which is approximately 60 km in length. The Sub-Region has a total peak demand of 106 MW and is expected to grow to 122 MW by year 2023. During planned or forced outages the interrupted load in the Sub-Region can be transferred to the backup 115 kV circuit T11T.

Under pre-contingency conditions and with Erie Shores Wind Farm unavailable, the voltage at Tillsonburg TS 115 kV bus does not meet ORTAC criteria (113 kV) under existing peak load conditions and may reach as low as 100 kV. The transformer ULTCs at Tillsonburg TS is however maintaining the LV bus voltage above ORTAC criteria of 27 kV (98% of nominal voltage). Study results indicate that the LV voltage cannot be maintained at desirable levels when the load in the Aylmer-Tillsonburg Sub-Region exceeds 115 MW. Based on the latest load forecasts, this loading level may be reached as early as 2019.

The voltage constraint is further described in section 7.2.1 of this report.

6.5 Customer Delivery Point Performance

In accordance with Section 2.5 of the Transmission System Code, Hydro One Networks Inc. (Networks) is required to develop performance standards at the customer delivery point level, consistent with system wide standards that reflect:

- typical transmission-system configurations that take into account the historical development of the transmission system at the customer delivery point level;
- historical performance at the customer delivery point level;
- acceptable bands of performance at the customer delivery point level for the transmission system configurations; geographic area, load, and capacity levels; and

- defined triggers that would initiate technical and financial evaluations by the transmitter and its customers regarding performance standards at the customer delivery point level, exemptions from such standards, and study triggers and results.

The Customer Delivery Point Performance Standards and triggers are based on the size of load being served (as measured in megawatts by a delivery point's total average station load) are provided in Table 6-4 below.

Table 6-4 Customer Delivery Point Performance Standards

Performance Measure	Delivery Point Performance Standards *(Based on a Delivery Point's Total Average Station Load)*							
	0-15 MW		**15-40 MW**		**40-80 MW**		**>80 MW**	
	Standard (Average Performance)	Minimum Standard of Performance	Standard (Average Performance)	Minimum Standard of Performance	Standard (Average Performance)	Minimum Standard of Performance	Standard (Average Performance)	Minimum Standard of Performance
DP Frequency of Interruptions (Outages/year)	4.1	**9.0**	1.1	**3.5**	0.5	**1.5**	0.3	**1.0**
DP Interruption Duration (min/year)	89	**360**	22	**140**	11	**55**	5	**25**

The minimum standards of performance are to be used as triggers by Networks to initiate technical and financial evaluations with affected customers. These bands are to:

- accommodate normal year-to-year delivery point performance variations;
- limit the number of delivery points that are to be considered "performance outliers" to a manageable/affordable level;
- deliver a level of reliability that is commensurate with customer value i.e. the larger the load, the greater the level of reliability provided; and
- direct/focus efforts for reliability improvements at the "worst" performing delivery points.

The customer delivery points serving THI and HONI distribution at Tillsonburg TS is not meeting CDPPS requirements with regards to frequency of interruptions. This customer delivery point has averaged approximately 3.3 interruptions per year over the past 10 years, doubling the performance target of 1.5.

The Customer Delivery Point Performance need is further described in section 7.2.3 of this report.

6.6 End-of-Life Equipment Replacements

Recent condition assessment of Wonderland TS has revealed that one of the existing power transformers at the station (T5) is in poor condition and must be replaced in the near-term. The facility was originally built in the 1960s and its assets are degrading in condition and require replacement by 2022. The existing 230/28kV T6 power transformer was replaced in 2004 due to failure. The existing 230/28 kV T5 power transformer will be replaced with a similar unit (230kV-28kV 83 MVA) to match the ratings of transformer T6. After the transformer replacement is completed, the LTR of Wonderland TS is expected to increase to approximately 114MW.

7. REGIONAL NEEDS & PLANS

THIS SECTION DISCUSSES THE ELECTRICAL INFRASTRUCTURE NEEDS, POSSIBLE WIRES ALTERNATIVES AND SUMMARIZES THE CURRENT PREFERRED WIRES SOLUTION FOR ADDRESSING THE ELECTRICAL SUPPLY NEEDS IN THE LONDON AREA REGION

The needs listed in Table 7-1 include needs previously identified in the IRRP for the Greater London Sub-Region and the NA and LP's for the Strathroy, Woodstock, Aylmer-Tillsonburg and St. Thomas Sub-Regions.

The near-term needs include needs that arise over the first five years of the study period (2016 to 2020) and the mid-term needs cover the second half of the study period (2021-2025).

Table 7-1 Identified Near-Term Needs in London Region

Sub-Region	Type	Section	Needs	Timing
Woodstock Sub-Region	Load Restoration	7.1.1	Loss of M31W/M32W	No action required at this time
Greater London Sub-Region		7.1.2	Loss of W36/W37 or W42L/W43L	Now
Aylmer-Tillsonburg Sub-Region	Voltage Constraint	7.2.1	Voltage at Tillsonburg TS below ORTAC criteria	Now
	Thermal Constraint	7.2.2	Thermal constraint on 115kV line W8T	Now
	Delivery Point Performance	7.2.3	Poor delivery point performance at Tillsonburg TS	Now

7.1 Load Restoration

7.1.1 Woodstock Sub-Region: Loss of M31W/M32W

Description

The Woodstock Sub-Region load restoration need was identified in the NA and LP reports and further assessment was recommended to address the supply shortfall during peak load periods. Previous assessments indicated that in case of loss of two transmission elements (M31W/M32W), the load interrupted with current circuit configuration during peak periods may exceed load restoration criteria.

Recommended Plan and Current Status

A local planning report[7] was completed to develop a plan to address the load restoration need identified in the Sub-Region. The report concluded the following:

For Woodstock Sub-Region, the critical line section is M31W/M32W tap between Salford Junction and Ingersoll Junction. Should a contingency on this line section occur, all of the sub-region's load, which amounted to 188 MW in 2016, would be interrupted by configuration.

Under such emergency conditions, depending on system performance and availability of switching facilities, all or a portion of a load station could be restored by transferring load to neighbouring unaffected supply. Hydro One Distribution estimated that 10 MW of load at Ingersoll TS could be transferred to Highbury TS. Another 8 MW could be transferred from Commerce Way TS to Tillsonburg TS on the feeder level. On the transmission side, the supply from Brant TS will be able to restore about 20 MW of load in the Woodstock Sub-Region.

These measures can be deployed remotely to manage and mitigate the impact of the loss of two transmission elements within the 4 hours timeframe. To restore the remaining 150 MW of interrupted load within 8 hours, field crews from the nearest staffed centre in London Area will be dispatched to install temporary fixes on the transmission system such as building an emergency by-pass.

The Working Group is recommending that no further action is required at this time.

7.1.2 Greater London Sub-Region: Loss of W36/W37 or W24L/W43L

The Greater London Sub-Region load restoration need was identified in the NA and IRRP reports and further assessment was recommended to address the supply shortfall during peak load periods. Previous assessments indicated that for the loss of two transmission elements (W36/W37 or W42L/W43L), the load interrupted with the current circuit configuration during peak periods may exceed load restoration criteria.

W36/W37 – Clarke TS and Talbot TS

Description

Clarke TS and Talbot TS are supplied by 230 kV transmission circuits W36/W37 and have a total peak demand of 370 MW. Following the loss of both W36 and W37, supply to Clarke TS and Talbot TS would be interrupted.

[7] Woodstock Restoration Local Planning Report – May 30, 2017

Under such emergency conditions, London Hydro can currently restore up to 55 MW of interrupted load through distribution system transfers within 30 minutes and up to 105 MW within four hours. The interrupted load would be transferred to Wonderland TS, Buchanan TS and Highbury TS during such events. As part of the rebuild of Nelson TS in 2018, the station's LV bus will be converted from 13.8 kV to 27.6 kV. After the conversion, Nelson TS will be able to provide additional backup capacity to support meeting the ORTAC timelines in the event of a double circuit outage. With the new 27.6 kV Nelson TS, a total of 95 MW of load can be restored within 30 minutes, and 150 MW of load within four hours. This reduces the 30 minute shortfall to 25 MW and the four hour shortfall to 71 MW in 2019.

Recommended Plan and Current Status

The Greater London Sub-Region IRRP [8] developed a plan to address the load restoration need identified in the Sub-Region. The report concluded the following:

Currently, London Hydro has 28 distribution feeders in total that emanate from Clarke TS and Talbot TS. Only half of these feeders are presently interconnected to other non-Clarke and non-Talbot feeders (i.e., Highbury, Buchanan, and Wonderland TS feeders). Installing approximately 10 additional automated switching devices in strategic locations on the distribution feeders could provide an additional 25 MW of load transfer capability within 30 minutes for Clarke TS and Talbot TS load. These switching devices are estimated to cost approximately $0.6 million.

An additional 10-15 MW of load restoration support for longer-term relief (more than 30 minutes) could be provided by extending the 14 existing Clarke and Talbot feeders to connect with feeders from non-connected neighboring stations. For example, a 3.7 km Talbot feeder line extension to connect to a Wonderland feeder at an approximate cost of $1.2 million could provide support to 10-15 MW of load for the Clarke TS and Talbot TS load pockets.

For a unit cost of $180/kW, the Working Group is recommending the implementation of automated switching devices and feeder extensions on the Distribution System as the most cost effective method to substantially mitigate the restoration shortfall in this area.

These solutions would also maximize the use of existing distribution infrastructure and provide flexibility to London Hydro to manage load between different stations in its service territory.

It is important to note that the feeder capacity margins are not static and will reduce as the 20-year projected load growth at the transformer stations materializes. Hence, the amount of load that can be restored using the distribution system in the event of a double element loss of supply to Clarke TS and Talbot TS will reduce over time. Consequently, part of the recommendation is that London Hydro continues to monitor load growth and relevant feeder limits in its service territory. The Working Group recommends the actions described below to meet the restoration need identified for the Greater London

[8] Greater London Sub-Region, Integrated Regional Resource Plan – January 20, 2017

Sub-region. Successful implementation of this plan will substantially address the restoration need in this sub-region for the next decade.

W42L/W43L – Buchanan TS

In case of loss of theW42L/W43L transmission lines, the load supplied from Buchanan TS which reaches slightly over 150 MW would be interrupted by configuration.

Under such emergency conditions, London Hydro can transfer any interrupted load in excess of 150 MW to adjacent stations within the service area. These measures to manage and mitigate the impact of the equipment loss can be deployed within the 4 hours timeframe. To restore the remaining 150 MW of interrupted load within 8 hours, field crews from the nearest staffed centre in London area will be dispatched to install temporary fixes on the transmission system such as building an emergency by-pass.

The Working Group is recommending that no further action is required at this time.

7.2 Aylmer-Tillsonburg Sub-Region: Voltage/Thermal Constraint & Delivery Point Performance

The Aylmer-Tillsonburg Sub-Region is primarily supplied by a single 115 kV transmission circuit W8T. The Sub-Region has a total peak demand of 106 MW and is expected to grow to 122 MW by year 2023. During planned or forced outages the interrupted load in the Sub-Region can be transferred to the backup 115 kV circuit T11T. The Tillsonburg TS voltage constraint and the W8T thermal constraint need was identified in the NA report and further assessment was recommended to address these needs. Following the NA report, the Working Group further identified Delivery Point Performance needs at Tillsonburg TS. These needs are assessed as part of this RIP.

7.2.1 Voltage Constraint

The voltage constraint observed on the 115 kV bus at Tillsonburg TS results from having a long 65 km 115 kV single circuit supply, a large 90 MW Tillsonburg TS load at the end of the transmission line, and a lack of reactive power support at the station to compensate. To mitigate the voltage constraints at Tillsonburg TS, the Working Group considered the following options.

Installation of Shunt Capacitors at Tillsonburg TS

One method to mitigate the voltage constraints at Tillsonburg TS is to provide reactive power compensation at the station. Installation of shunt capacitor banks (2 x 21 Mvar) on the 27.6 kV bus at Tillsonburg TS provides the necessary reactive compensation to meet the ORTAC voltage criteria (113 kV) for the peak load forecast over the study period of 89 MW at Tillsonburg TS. Further, the shunt capacitors are capable of supporting future load growth beyond the study period up to 109 MW – equal to the LTR rating of Tillsonburg TS. These shunt capacitor banks are estimated to cost approximately $8 million.

Installation of Switching at Buchanan TS and Reconfiguration of 115 kV Circuits

Another method to mitigate the voltage constraints at Tillsonburg TS is to reconfigure the 115 kV circuits supplying the Aylmer-Tillsonburg Sub-Region. A single line diagram of the Aylmer-Tillsonburg Sub-Region after the decommissioning of St. Thomas TS is shown in Figure 7-1.

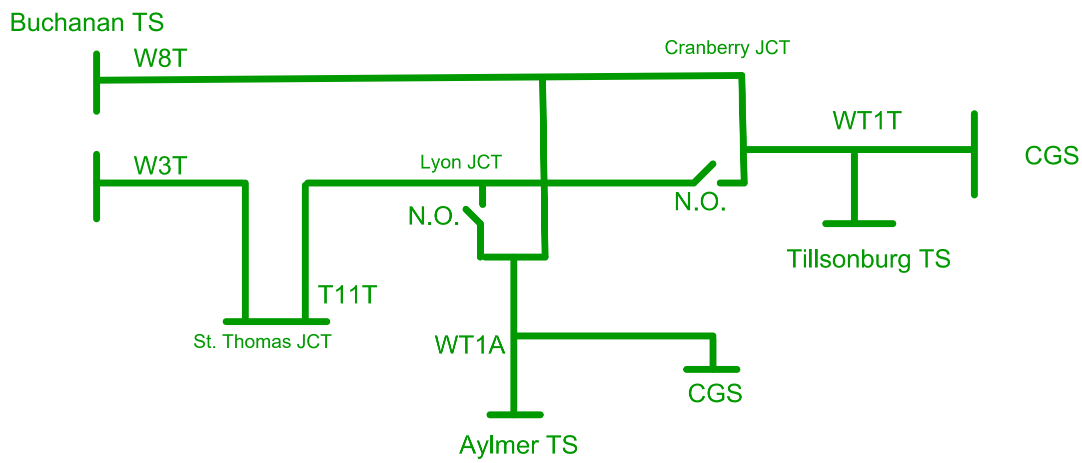


Figure 7-1 Existing Single Line Diagram of Aylmer-Tillsonburg Sub-Region

Aylmer TS and Tillsonburg TS are normally supplied by 115 kV circuit W8T. Reconfiguring the system so that Aylmer TS and Tillsonburg TS are normally supplied by both W8T and T11T reduces the system impedance and improves the voltages in the area. The reconfiguration of the 115 kV system requires installing new switches at Buchanan TS to tie 115 kV circuits W8T and W3T. The "normally open" switches at Lyon JCT and Cranberry JCT will be changed to "normally closed". Lastly the protection relaying at Buchanan TS will require upgrades/modification. A single line diagram of the Aylmer-Tillsonburg Sub-Region after the reconfiguration is shown in Figure 7-2.

The voltages at the Tillsonburg TS 115 kV bus after the reconfiguration improve to 113 kV, meeting the ORTAC voltage criteria for the peak load forecast over the study period. Any further load growth beyond the peak load forecast of 89 MW at Tillsonburg TS will cause the voltage at Tillsonburg TS 115 kV bus to fall below the ORTAC voltage criteria of 113 kV. Similar to the current situation, the transformer ULTCs at Tillsonburg TS can maintain the LV bus voltage above the ORTAC criteria of 27 kV (98% of nominal voltage) for load growth up to 109 MW – equal to the LTR rating of Tillsonburg TS. Reconfiguration of the 115 kV system is estimated to cost approximately $4 million.

While the reconfiguration of the 115 kV system mitigates the voltage constraint need over the study period, it potentially worsens the customer delivery point performance of Tillsonburg Hydro and Hydro One Distribution at Tillsonburg TS. Frequency of outages is expected to increase slightly resulting from higher exposure to lightning and wind events. In addition, restoration times are expected to increase slightly due to the incremental switching requirements.

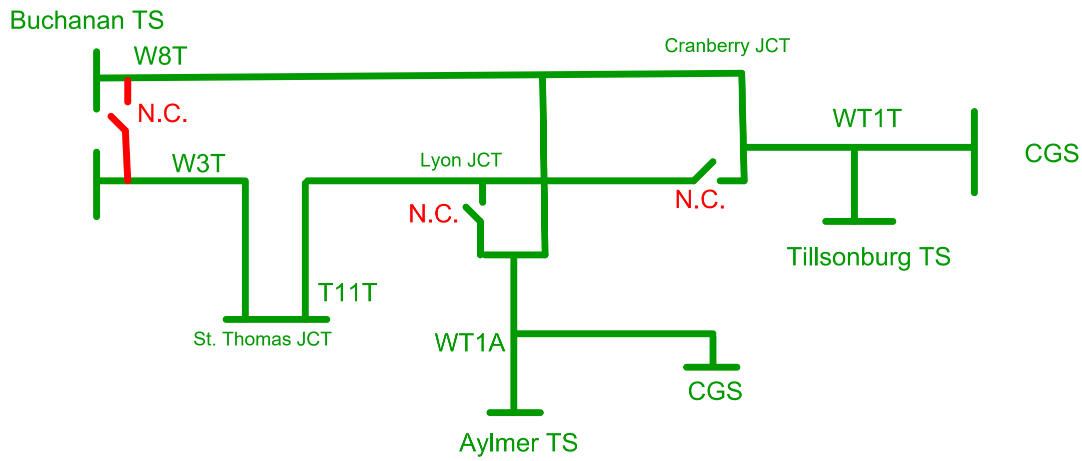


Figure 7-2 Single Line Diagram of Aylmer-Tillsonburg Sub-Region after Reconfiguration

7.2.2 Thermal Constraint

Thermal constraints are observed on a section of line approximately 1.5 km long on 115 kV circuit W8T between Buchanan TS and Edgeware JCT. Under pre-contingency conditions, the thermal loading on this section line reaches 140% of its planning rating of 590A based on the peak load forecast over the study period. Implementing either one of the options in section 7.2.1 to mitigate the voltage constraint at Tillsonburg TS substantially improves the thermal loading on this section line.

Reconfiguring the 115 kV system in the Aylmer-Tillsonburg Sub-Region and installing new switches at Buchanan TS to mitigate the voltage constraint at Tillsonburg TS also mitigates the thermal constraint on circuit W8T.

Installing capacitor banks at Tillsonburg TS reduces the loading on this section of W8T to 106% of its planning rating. As a result, upgrading this section of line would be required to increase the planning to rating to address the thermal overload based on the peak load forecast over the study period. Thirteen poles are required to be replaced at an estimated cost of $1.5 million. This will raise the planning rating of the line to match the other sections of circuit W8T.

A thermal constraint on a section of line approximately 1.5 km long on 115 kV circuit WT1T between Cranberry JCT and Tillsonburg TS was previously identified in the NA report. Tillsonburg Hydro has since provided a revised load forecast and there is no longer an overloading in this section of line.

7.2.3 Customer Delivery Point Performance

The Tillsonburg TS customer delivery point performance need was identified by the Working Group after the NA report was completed. Historical values indicated that the frequency of outages to Tillsonburg Hydro and Hydro One Distribution fall below the standards per Hydro One's "Customer Delivery Point Performance Standard" which is approved by the OEB.

The vast majority of interruptions to Tillsonburg Hydro and Hydro One Distribution at Tillsonburg TS results from having only one normal transmission supply to Tillsonburg TS. One method which substantially improves customer delivery point performance is to provide a second transmission circuit to supply Tillsonburg TS. In most situations, a second supply is normally cost prohibitive. Tillsonburg TS however is in a situation where there is an existing backup 115 kV circuit T11T within 3.5 km of the station. A second transmission supply to Tillsonburg TS would require extending 115kV circuit T11T from Cranberry JCT to Tillsonburg TS, HV bus work at Tillsonburg TS and protection relaying modifications and upgrades at Buchanan TS. Providing a second transmission supply to Tillsonburg TS is estimated to cost approximately $16 million.

7.2.4 Aylmer-Tillsonburg Sub-Region Recommended Plan

The Working Group examined various options to address the voltage, thermal and customer delivery point performance needs of the Sub-Region. The needs, options and alternatives are summarized in Tables 7-2, 7-3 and 7-4 respectively.

Table 7-2 Aylmer-Tillsonburg Sub-Region Needs

Need ID	Needs	Timing
I	Voltage constraint at Tillsonburg TS	Existing
II	Thermal constraint on W8T (Buchannan X Edgeware JCT)	Existing
III	Customer Delivery Point Performance below standards at Tillsonburg TS	Existing

Table 7-3 Aylmer-Tillsonburg Sub-Region Need Mitigation Options

#	Project	Lead Responsibility	I/S Date	Estimated Cost	Mitigated Need ID
1	Installation of Shunt Capacitors at Tillsonburg TS	HONI	2021	$8M	I
2	Installation of Switching at Buchanan TS and Reconfiguration of 115 kV Circuits	HONI	2019	$4M	I & II
3	W8T Circuit Upgrade	HONI	2021	$1.5M	II
4	Second transmission circuit supply to Tillsonburg TS	THI & HONI	2021	$16M	II & III

After further assessing the needs in Aylmer-Tillsonburg Sub-Region, the Working Group proposed a number of different options to mitigate the voltage, thermal and customer delivery point performance needs. Due to the complexity of the projects examined, it was determined that further assessment to clarify scope and specifically the cost details is needed. As such, the Working Group recommends Hydro One to pursue Budgetary Cost Estimates in order to obtain the necessary information to properly analyze the cost and benefits of each alternative.

Hydro One plans to obtain Budgetary Cost Estimates for the alternatives proposed and provide back the results to the Working Group by Q4 2018 in order to continue the planning activities for the Sub-Region.

Table 7-4 Aylmer-Tillsonburg Sub-Region Alternatives

Alternatives	Benefits/	Total Cost
I	Proceed with Projects I, III and IV -Resolves all three needs in the sub-region	$25.5M
II	Proceed with Project II -Resolves need I & II of the sub-region -Increase in the frequency interruptions at Tillsonburg TS -Lengthens restoration time (slightly) during forced outages -During planned or forced outages to W8T or T11T, switches at Buchanan, Lyon JCT and Cranberry JCT will be opened negating the voltage support effects	$4M
III	Proceed with Projects I and III -Resolves needs I & II in the sub-region	$9.5M

7.3 Long Term Regional Plan

As discussed in Section 5, the electricity demand in the London Area Region is expected to remain relatively constant over the study period (approximate growth rate of -0.3%). Load growth over the long term period is expected to be moderate (up to 1.5%) from 2027 to 2037. Long term forecast provides a high level insight of how the region may be developing in the future so that near and mid-term plans and ongoing projects in the region are best aligned with potential long term needs and solutions.

No long term needs for the London Area Region have been identified at this time. If new needs emerge due to a change in load forecast or any other reason, a new regional planning cycle will be initiated ahead of the 5-year planning cycle.

8. CONCLUSION AND NEXT STEPS

THIS RIP REPORT CONCLUDES THE REGIONAL PLANNING PROCESS FOR THE LONDON AREA REGION. THIS REPORT MEETS THE INTENT OF THE PROCESS DESCRIBED IN SECTION 2 WHICH IS ENDORSED BY THE OEB AND MANDATED IN THE TSC AND DSC.

This RIP report addresses regional needs identified in the earlier phases of the Regional Planning process and any new needs identified during the RIP phase. These needs are summarized in Table 8-1.

Table 8-1 Regional Plans – Needs Identified in the Regional Planning Process

Need ID	Needs	Timing
I	Woodstock Sub-Region load restoration	Now
II	Greater London Sub-Region load restoration	Now
III	Voltage constraint at Tillsonburg TS	Now
IV	Thermal constraint on W8T	Now
V	Poor delivery point performance at Tillsonburg TS	Now
VI	EOL Asset – Wonderland TS transformer T5	2022

Projects, lead responsibility, and timeframes for implementing the wires solutions for the above needs are summarized in Table 8-2 below.

Table 8-2 Regional Plans – Projects, Lead Responsibility, and Planned In-Service Dates

#	Project	Lead Responsibility	I/S Date	Estimated Cost[9]	Mitigated Need ID
1	Distribution System Upgrades in the Greater London Sub-Region	London Hydro Inc.	2023	$1.8-4M ($180/kW)	II
2	Wonderland TS Reinvestment: Replace transformer T5	Hydro One Transmission	2022	$15-20M	VI

Woodstock Sub-Region load restoration need (Need ID I) was assessed by the Working Group during Local Planning and "status quo/do nothing" course of action has been recommended. Further developments in the Region will be monitored and the need will be reviewed again as part of the next planning cycle.

[9] Costs presented are preliminary estimate and may change resulting from clarification of scope and through detailed cost estimating.

Greater London Sub-Region load restoration need (Need ID II) was further assessed during Integrated Regional Resource Planning and the Working Group is recommending the implementation of automated switching devices and feeder extensions on the Distribution System as the most cost effective method to substantially mitigate the restoration shortfall in this area.

Due to the various needs of the Aylmer-Tillsonburg Sub-Region and the complexity of the options proposed, the Working Group is recommending Budgetary Cost Estimates be completed in order to obtain the necessary information to properly analyze the cost and benefits of each alternative.

In accordance with the Regional Planning process, the Regional Planning cycle will be triggered at least once within five years. Should there be a need that emerges due to a change in load forecast or any other reason, the next regional planning cycle will be started earlier to address the need.

9. REFERENCES

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APPENDICES

Appendix A: Stations in the London Area Region

Station Name	Voltage Level	Supply Circuits
Strathroy TS	230/27.6kV	W2S, S2N
Talbot TS	230/27.6kV	W36, W37
Clark TS	230/27.6kV	W36, W37
Wonderland TS	230/27.6kV	N21W, N22W
Buchanan TS	230/27.6kV	W42L, W43L
Nelson TS	115/27.6kV[10]	W5N, W6NL
Longwood TS	230/27.6kV	L24L, L26L
Highbury TS	115/27.6kV	W6NL, W9L
Ingersoll TS	230/27.6kV	M31W, M32W
Woodstock TS	115/27.6kV	K7, K12
Commerceway TS	115/27.6kV	K7, K12
Aylmer TS	115/27.6kV	W8T, T11T, WT1A
Tillsonburg TS	115/27.6kV	W8T, T11T, WT1T
St. Thomas TS	115/27.6kV	W3T, W4T, T11T
Edgeware TS	230/27.6kV	W45LS, W44LC

[10] As part of the Nelson TS rebuild planned to be completed by year end 2018, the low voltage bus is being converted from 13.8 kV to 27.6 kV

Appendix B: Non-Coincident Load Forecast 2016-2025

*Gross Load Forecast - Median Weather

Transformer Station Name	LDC/Customer	DESN ID	10-DAY SLTR (MW)	Customer Data	Historical Data (MW)			Near Term Forecast (MW)					Medium Term Forecast (MW)		
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Aylmer TS	Hydro One	*T2/T3*	*18.4*	Gross Peak Load				7	7	7	7	7	7	7	7
	Erie Thames			Gross Peak Load				15	19	19	26	27	27	27	28
				DG				0	0	0	0	0	0	0	0
				CDM				0	1	1	1	2	2	2	2
				Net Load Forecast	21	21	21	21	25	25	32	32	32	33	33
Buchanan TS	Hydro One	*T13/T14*	*183*	Gross Peak Load				10	11	11	11	11	11	11	11
	London Hydro			Gross Peak Load				127	144	146	145	147	148	150	151
				DG				1	1	1	1	1	1	1	1
				CDM				2	4	5	6	8	8	9	10
				Net Load Forecast	147	149	143	134	150	151	149	149	150	151	151
Clark TS	Hydro One	*T3/T4*	*110*	Gross Peak Load				14	14	14	14	14	14	15	15
	London Hydro			Gross Peak Load				95	96	97	98	99	93	94	95
				DG				2	3	3	3	3	3	3	3
				CDM				2	2	3	4	5	6	7	7
				Net Load Forecast	107	111	106	105	106	106	106	106	99	100	101
Commerceway TS	Hydro One	*T1/T2*	*112*	Gross Peak Load				38	34	34	34	34	34	34	34
				DG				0	0	0	0	0	0	0	0
								0	0	0	0	0	0	0	0
				CDM				1	1	1	1	2	2	2	2
				Net Load Forecast	42	33	33	37	33	33	32	32	32	32	32
Edgeware TS	Hydro One	*T1/T2*	*191*	Gross Peak Load				57	57	57	58	59	59	60	60
	London Hydro			Gross Peak Load				1	1	1	1	1	1	1	1
	St. Thomas			Gross Peak Load				52	52	52	52	53	53	53	53
				DG				1	1	1	1	1	1	1	1
				CDM				2	2	3	5	6	7	7	8
				Net Load Forecast	116	97	98	106	106	106	105	105	105	105	105

Transformer Station Name	LDC/Customer	DESN ID	10-DAY SLTR (MW)	Customer Data	Historical Data (MW)			Near Term Forecast (MW)					Medium Term Forecast (MW)		
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Highbury TS	Hydro One	*T3/T4*	*114*	Gross Peak Load				6	7	7	7	7	7	7	7
	London Hydro			Gross Peak Load				88	88	89	83	84	91	92	93
				DG				4	4	4	4	4	4	4	4
				CDM				2	2	3	4	5	6	6	7
				Net Load Forecast	92	93	93	88	88	89	82	82	88	88	89
Ingersoll TS	Hydro One	*T5/T6*	*167*	Gross Peak Load				38	38	38	38	38	38	38	38
	Erie Thames			Gross Peak Load				39	40	40	40	40	40	40	40
				DG				6	6	6	6	6	6	6	6
				CDM				1	2	2	3	4	5	5	6
				Net Load Forecast	76	74	75	70	70	69	68	67	67	67	66
Longwood TS	Hydro One	*T13/T14*	*128*	Gross Peak Load				33	33	34	34	35	36	36	37
				DG				0	0	0	0	0	0	0	0
				CDM				1	1	1	1	2	2	2	3
				Net Load Forecast	39	32	30	32	32	32	33	33	33	34	34
Nelson TS	London Hydro	*T1/T2*	*105*	Gross Peak Load				16	17	15	52	58	59	60	61
				DG				0	0	0	0	15	15	15	15
				CDM				1	1	1	2	2	2	2	2
				Net Load Forecast	45	42	23	16	16	14	50	42	42	43	44
St Thomas TS	St. Thomas	*T3/T4*	*50*	Gross Peak Load				0	0	0	0	0	0	0	0
				DG				0	0	0	0	0	0	0	0
								0	0	0	0	0	0	0	0
				CDM				0	0	0	0	0	0	0	0
				Net Load Forecast	5	1	1	0	0	0	0	0	0	0	0

Transformer Station Name	LDC/Customer	DESN ID	10-DAY SLTR (MW)	Customer Data	Historical Data (MW)			Near Term Forecast (MW)					Medium Term Forecast (MW)		
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Strathroy TS	Hydro One	*T1/T2*	*50*	Gross Peak Load				15	15	15	16	16	16	16	16
	Entegrus			Gross Peak Load				33	34	34	34	35	35	35	36
				DG				1	1	1	1	1	1	1	1
				CDM				1	1	1	2	3	3	3	4
				Net Load Forecast	44	45	45	46	46	47	46	46	47	47	47
Talbot TS	London Hydro	*T1/T2/T3 /T4*	*290*	Gross Peak Load				273	277	282	258	254	256	263	265
				DG				0	0	0	0	0	0	0	0
				CDM				5	7	10	13	14	15	17	18
				Net Load Forecast	242	247	268	268	270	272	245	240	241	246	247
Tillsonburg TS	Hydro One	*T1/T3*	*109*	Gross Peak Load				50	50	51	51	52	53	53	54
	Tillsonburg Hydro			Gross Peak Load				37	38	39	40	41	41	42	42
				DG				0	0	0	0	0	0	0	0
				CDM				2	2	2	4	5	6	6	7
				Net Load Forecast	94	81	88	85	86	87	88	88	89	89	89
Wonderland TS	Hydro One	*T5/T6*	*99*	Gross Peak Load				9	9	9	9	9	9	9	9
	London Hydro			Gross Peak Load				104	90	92	90	92	94	90	92
				DG				1	1	1	1	1	1	1	1
				CDM				2	2	3	4	5	5	6	7
				Net Load Forecast	109	109	109	110	96	97	94	95	97	92	93
Woodstock TS	Hydro One	*T1/T2*	*87*	Gross Peak Load				68	68	68	69	69	69	69	70
				DG				3	3	3	3	3	3	3	3
				CDM				1	1	2	3	4	4	4	5
				Net Load Forecast	62	55	56	64	64	64	63	62	62	62	62

Appendix C: Coincident Load Forecast 2016-2025

Station	Historical MW	Near Term Forecast (MW)					Medium Term Forecast (MW)		
	2015	2016	2017	2018	2019	2020	2021	2022	2023
Aylmer TS	18	18	20	21	22	23	25	27	28
Buchanan TS	126	125	127	129	131	133	135	138	141
Clark TS	96	92	92	91	90	89	88	87	88
Commerceway TS	25	24	23	23	22	21	21	20	20
Edgeware TS	105	103	103	103	102	102	102	102	102
Highbury TS	77	72	72	72	72	71	71	71	71
Ingersoll TS	70	63	63	62	61	60	60	60	59
Longwood TS	31	30	30	31	31	31	31	31	32
Nelson TS	16	16	16	14	50	42	42	43	44
St Thomas TS	0	0	0	0	0	0	0	0	0
Talbot TS	267	261	257	253	249	247	245	242	240
Tillsonburg TS	91	91	92	92	92	92	93	94	95
Wonderland TS	103	98	97	94	92	89	88	85	83
Woodstock TS	58	54	54	54	53	53	53	52	52

Appendix D: 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
CTS	Customer Transformer Station
DESN	Dual Element Spot Network
DG	Distributed Generation
DSC	Distribution System Code
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