GREATER LONDON SUB-REGION INTEGRATED REGIONAL RESOURCE PLAN

Part of the London Area Planning Region | January 20, 2017

Connecting Today. Powering Tomorrow.

Integrated Regional Resource Plan

Greater London Sub-region

This Integrated Regional Resource Plan ("IRRP") was prepared by the Independent Electricity System Operator ("IESO") pursuant to the terms of its Ontario Energy Board licence, EI-2013-0066.

The IESO prepared the IRRP on behalf of the Greater London Sub-Region Working Group (the "Working Group"), which included the following members:

- Independent Electricity System Operator
- London Hydro Inc.
- Hydro One Networks Inc. (Distribution)
- Hydro One Networks Inc. (Transmission)

The Working Group assessed the adequacy of electricity supply to customers in the Greater London Sub-region over a 20-year period; developed a flexible, comprehensive, integrated plan that considers opportunities for coordination in anticipation of potential demand growth scenarios and varying supply conditions in the Greater London Sub-region and developed an implementation plan for the recommended options, while maintaining flexibility in order to accommodate changes in key conditions over time.

The Working Group members agree with the IRRP's recommendations and support implementation of the plan through the recommended actions, subject to obtaining all necessary regulatory and other approvals.

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Abbreviations	Descriptions
CHP	Combined Heat and Power
CHPSOP	Combined Heat and Power Standard Offer Program
CDM or Conservation	Conservation and Demand Management
DG	Distributed Generation
DR	Demand Response
FIT	Feed-in Tariff
Hydro One	Hydro One Networks Inc.
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kV	Kilovolt
LAC	Local Advisory Committee
LDC	Local Distribution Company
LMC	Load Meeting Capability
London Hydro	London Hydro Inc.
LTEP	(2013) Long-Term Energy Plan
MW	Megawatt
OEB or Board	Ontario Energy Board
OPA	Ontario Power Authority
ORTAC	Ontario Resource and Transmission Assessment Criteria
PPWG	Planning Process Working Group
PPWG Report	Planning Process Working Group Report to the Board
RIP	Regional Infrastructure Plan
TS	Transformer Station
TWh	Terawatt-Hours
Working Group	Technical Working Group for Greater London Sub-region IRRP

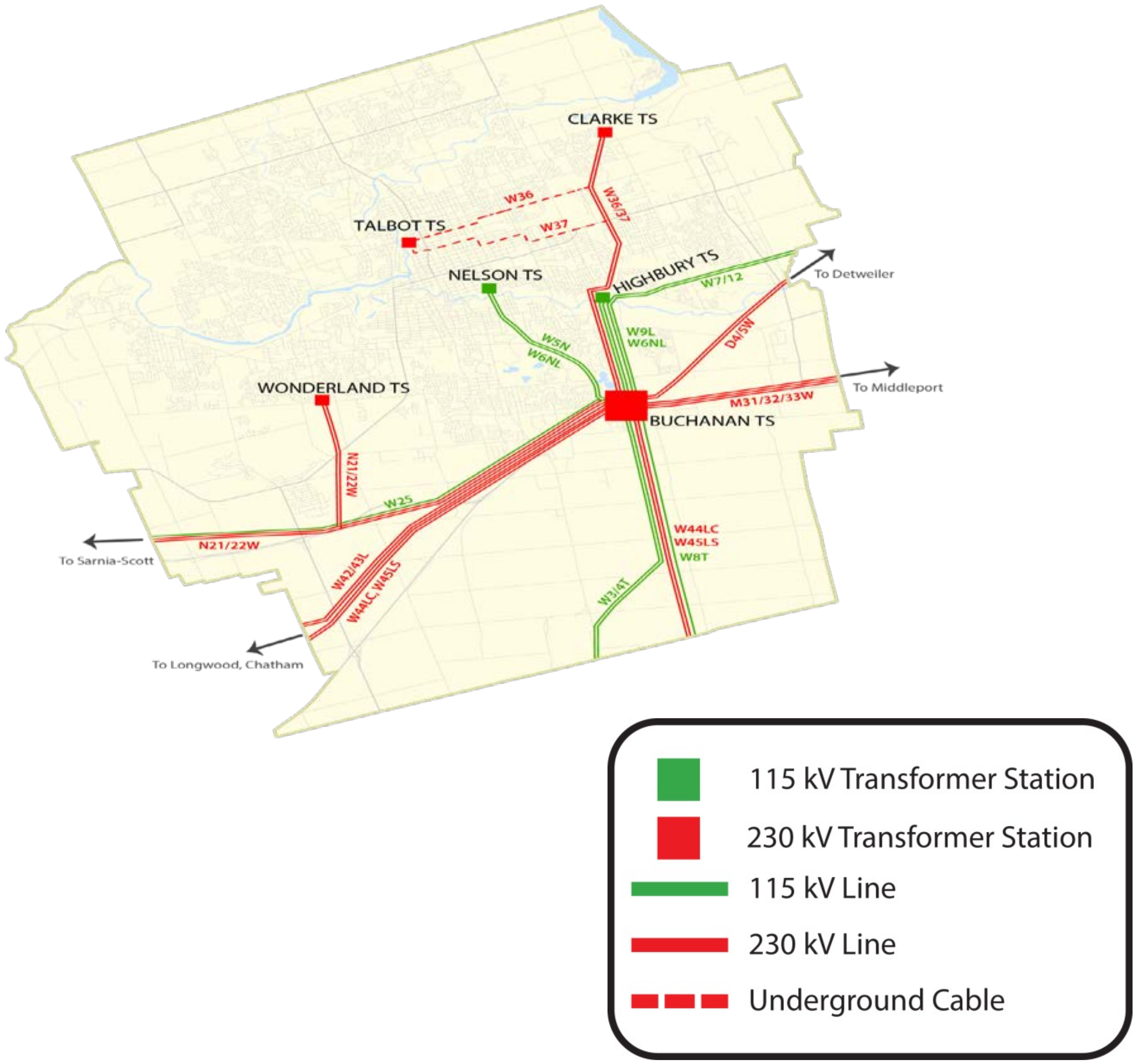
1. Introduction

This Integrated Regional Resource Plan ("IRRP") addresses the electricity needs for the Greater London Sub-region over the next 20 years. This report was prepared by the Independent Electricity System Operator ("IESO") on behalf of a technical working group composed of the IESO, London Hydro Inc. ("London Hydro"), Hydro One Distribution and Hydro One Transmission[1] (the "Working Group").

The Greater London Sub-region is within the London Area planning region. The London Area planning region is one of the 21 planning regions identified by the OEB's regional planning process. In municipal terms the Greater London Sub-region roughly encompasses the City of London and parts of Middlesex County. The study is focused on the areas served by the following transformer stations ("TS"): Buchanan DESN, Clarke, Highbury, Nelson, Talbot and Wonderland.[2] The area is served by the 230 kilovolt ("kV") transmission circuits W36/37, N21/22W, W42/43L, and the 115 kV circuits W5N/W6NL/W9L, and the 230/115 kV autotransformers at Buchanan TS. The study area, including all area transformer stations, is shown in Figure 1-1.

[1] For the purpose of this report, "Hydro One Transmission" and "Hydro One Distribution" are used to differentiate the transmission and distribution accountabilities of Hydro One Networks Inc. ("Hydro One"), respectively.
[2] Some customers served by these stations reside outside the sub-region boundaries.

Figure 1-1: Map of Greater London Sub-region



In Ontario, planning to meet the electrical supply and reliability needs of a large area or region is done through regional electricity planning, a process that was formalized by the Ontario Energy Board ("OEB" or "Board") in 2013. In accordance with the OEB regional planning process, transmitters, distributers and the IESO are required to carry out regional planning activities for 21 electricity planning regions at least once every five years.

This IRRP identifies power system capacity and reliability requirements, and coordinates the options to meet customer needs in the sub-region over the next 20 years. Specifically, this IRRP identifies actions for implementation necessary to meet near- and medium-term needs in the sub-region, respecting the lead time for development.

This IRRP also identifies factors that could lead to needs in the longer term. However given forecast uncertainty, the longer development lead time and the potential for technological change, the plan maintains flexibility for long-term options and does not recommend specific projects at this time. Instead, the long-term plan identifies actions to consider and develop alternatives, engage with the community and gather information and lay the groundwork for future options. These actions are intended to be completed before the next IRRP cycle, scheduled to begin in 2020 or sooner, depending on demand growth, so that the results can inform decisions should any decisions need to be made at that time.

This report is organized as follows:

- A summary of the recommended plan for the Greater London Sub-region is provided in Section 2;
- The process and methodology used to develop the plan are discussed in Section 3;
- The context for electricity planning in the Greater London Sub-region and the study scope are discussed in Section 4;
- Demand forecast scenarios, and conservation and distributed generation ("DG") assumptions, are described in Section 5;
- Electricity needs in the Greater London Sub-region are presented in Section 6;
- Alternatives and recommendations for meeting needs are addressed in Sections 7 and 8;
- A summary of engagement to date and moving forward is provided in Section 9; and
- A conclusion is provided in Section 10.

2. The Integrated Regional Resource Plan

The Greater London Sub-region IRRP provides recommendations to address the forecast electricity needs in the area over the next 20 years, based on the application of the IESO's Ontario Resource and Transmission Assessment Criteria ("ORTAC"). This IRRP identifies forecast electricity needs in the sub-region over the near term (0-5 years, or 2015 through 2019), medium term (6-10 years, or 2020 through 2024) and longer term (11- 20 years, or 2025 through 2034). These planning horizons are distinguished in the IRRP to reflect the different levels of forecast certainty, lead time for development and planning commitment required over these time horizons. The IRRP was developed based on consideration of planning criteria, including reliability, cost, feasibility, flexibility, environmental and social factors, and maximization of the use of the existing electricity system, where it is economic to do so.

This IRRP identifies and recommends plans and/or specific projects for implementation in the near term. Near-term actions are identified to gather information and lay the groundwork for future options as required. These actions are intended to be completed before the next IRRP cycle so that their results can inform further discussion at that time.

2.1 Near- to Medium-Term Plan

Prior to the initiation of the regional planning process for this sub-region, London Hydro and Hydro One agreed to reconfigure Nelson TS, a major station supplying the City of London's downtown. The reconfiguration entails replacing the current 115/13.8 kV stepdown station with a new 115/27.6 kV station and rebuilding the downtown distribution network at 27.6 kV. These reconfigurations are expected to be completed for a 2019 in-service. This project will allow the integration of the London downtown distribution system with the surrounding 27.6 kV network, thus facilitating operational flexibility and providing backup capability to the critical downtown load. With the new Nelson TS in-service in 2019, London Hydro will be able to balance load across its entire service territory eliminating the station capacity need previously identified in Need Screening and Scoping Assessment reports for the London Area Region.

With respect to load restoration in this sub-region, capability to restore interrupted loads at the Clarke and Talbot transformer stations following multi-circuit high voltage line or underground cable outages currently does not meet the IESO's ORTAC standards on load restoration. The Working Group recommends that London Hydro consider the following actions to substantially address the identified restoration need in the sub-region:

1. Install automated switching devices on the existing distribution system where feasible to provide faster load restoration.
2. Extend existing feeders from Clarke TS and Talbot TS to other stations in the sub-region where feasible to provide additional load transfer capability.

2.2 Longer-Term Plan

Based on the electrical demand forecasts provided by London Hydro and Hydro One Distribution, the implementation of the recommended near- to medium-term portion of the plan and capital investment already underway is expected to substantially address needs in the Greater London Sub-region until the end of the study period.

The Working Group will work with the local communities to monitor leading indicators for growth in the Greater London Sub-region. This includes monitoring changes to growth targets, the composition and location of specific customer segments (residential, commercial, industrial) and effects on electricity related to the implementation of community energy plans and/or Ontario's Climate Change Action Plan. If these or other factors impact service reliability or capacity of the local electricity delivery systems, a new IRRP process may be initiated ahead of the 5-year planning cycle. The potential for other measures, such as incremental distributed generation ("DG") or demand response ("DR") programs, will continue to be discussed through engagement with local municipalities, and in particular as the nature of the long-term needs, alternatives, and associated costs become clearer.

3. Development of the IRRP

3.1 The Regional Planning Process

In Ontario, planning to meet the electricity needs of customers at a regional level is done through regional planning. Regional planning assesses the interrelated needs of a region—defined by common electricity supply infrastructure—over the near, medium, and long term and develops a plan to ensure cost-effective, reliable electricity supply. Regional plans consider the existing electricity infrastructure in an area, forecast growth and customer reliability, evaluate options for addressing needs, and recommend actions.

Regional planning has been conducted on an as needed basis in Ontario for many years. Most recently, the IESO carried out planning activities to address regional electricity supply needs. The IESO conducted joint regional planning studies with distributors, transmitters and other stakeholders in regions where a need for coordinated regional planning had been identified.

In the fall of 2012, the Board convened a Planning Process Working Group ("PPWG") to develop a more structured, transparent, and systematic regional planning process. This group was composed of industry stakeholders including electricity agencies, utilities, and stakeholders, and in May 2013, the PPWG released its report to the Board[3] ("PPWG Report"), setting out the new regional planning process. 21 electricity planning regions were identified in the PPWG Report, and a phased schedule for completion was outlined. The Board endorsed the PPWG Report and formalized the process timelines through changes to the Transmission System Code and Distribution System Code in August 2013, as well as through changes to the Ontario Power Authority's ("OPA") licence in October 2013. The OPA's licence changes required it to lead a number of aspects of regional planning. After the merger of the IESO and the OPA on January 1, 2015, the regional planning responsibilities identified in the OPA's licence were transferred to the IESO.

The regional planning process begins with a Needs Screening process performed by the transmitter, which determines whether there are needs requiring regional coordination. If regional planning is required, the IESO then conducts a Scoping Assessment to determine whether a comprehensive IRRP is required, which considers conservation, generation, transmission, and distribution solutions, or whether a more limited "wires" solution is the

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[3] http://www.ontarioenergyboard.ca/OEB/_Documents/EB-2011-0043/PPWG_Regional_Planning_Report_to_the_Board_App.pdf

preferable option such that a transmission and distribution focused Regional Infrastructure Plan ("RIP") can be undertaken instead. The Scoping Assessment determines what type of planning is required for each region. There may also be regions where infrastructure investments do not require regional coordination and so can be planned directly by the distributor and transmitter outside of the regional planning process. At the conclusion of the Scoping Assessment, the IESO produces a report that includes the results of the Scoping Assessment and a preliminary Terms of Reference. If an IRRP is the identified outcome, the IESO is required to complete the IRRP within 18 months. If an RIP is the identified outcome, the transmitter takes the lead and has six months to complete it. Both RIPs and IRRPs are to be updated at least every five years.

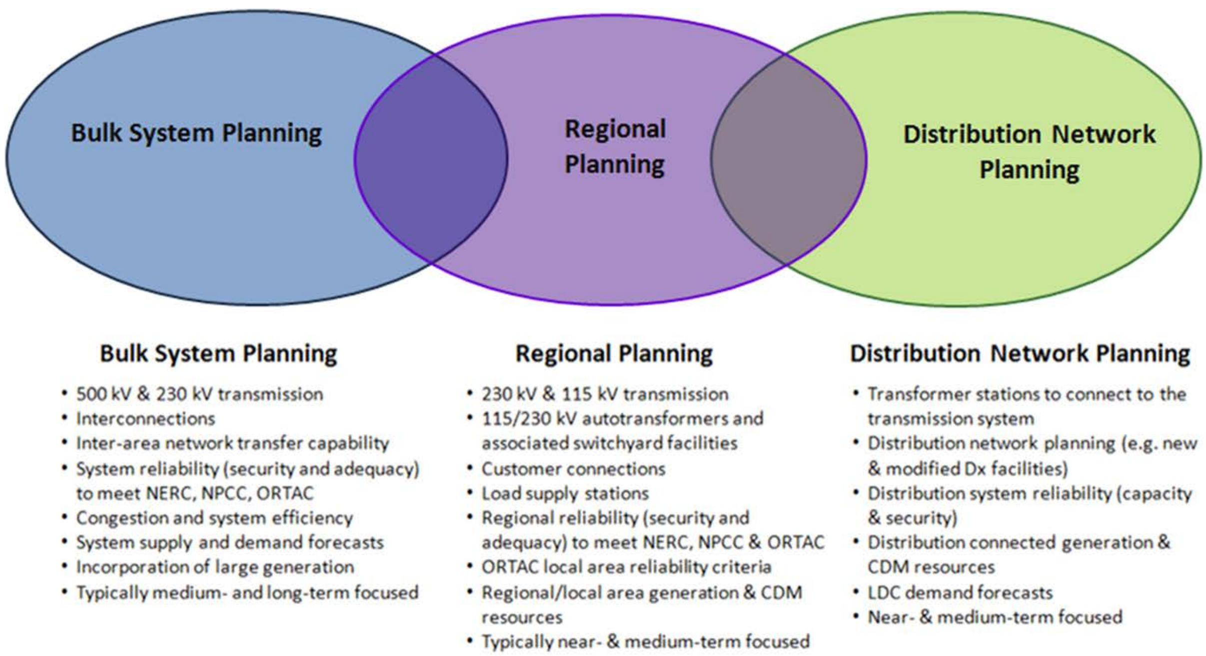
The final IRRPs and RIPs are posted on the IESO's and relevant transmitter's websites, and may be referenced and submitted to the Board as supporting evidence in rate or "Leave to Construct" applications for specific infrastructure investments. These documents are also useful for municipalities, First Nation communities and Métis community councils for planning, conservation and energy management purposes, as information for individual large customers that may be involved in the region, and for other parties seeking an understanding of local electricity growth, CDM and infrastructure requirements. Regional planning is not the only type of electricity planning that is undertaken in Ontario. As shown in Figure 3-1, there are three levels of planning that are carried out for the electricity system in Ontario:

- Bulk system planning
- Regional system planning
- Distribution system planning

Planning at the bulk system level typically considers the 230 kV and 500 kV network and examines province-wide system issues. Bulk system planning considers not only the major transmission facilities or "wires", but it also assesses the resources needed to adequately supply the province. This type of planning is typically carried out by the IESO pursuant to government policy. Distribution planning, which is carried out by Local Distribution Companies ("LDC"), considers specific investments in an LDC's territory at distribution level voltages.

Regional planning can overlap with bulk system planning. For example, overlaps can occur at interface points where there may be regional resource options to address a bulk system issue. Similarly, regional planning can overlap with the distribution planning of LDCs. For example, overlaps can occur when a distribution solution addresses the needs of the broader local area or region. Therefore, it is important for regional planning to be coordinated with both bulk and distribution system planning as it is the link between all levels of planning.

Figure 3-1: Levels of Electricity System Planning



By recognizing the linkages with bulk and distribution system planning, and coordinating multiple needs identified within a region over the long term, the regional planning process provides a comprehensive assessment of a region's electricity needs. Regional planning aligns near- and long-term solutions and puts specific investments and recommendations coming out of the plan in perspective. Furthermore, regional planning optimizes ratepayer interests by avoiding piecemeal planning and asset duplication, and allows Ontario ratepayer interests to be represented along with the interests of LDC ratepayers, and individual large customers. IRRPs evaluate the multiple options that are available to meet the needs, including conservation, generation, and "wires" solutions. Regional plans also provide greater transparency through engagement in the planning process, and by making plans available to the public.

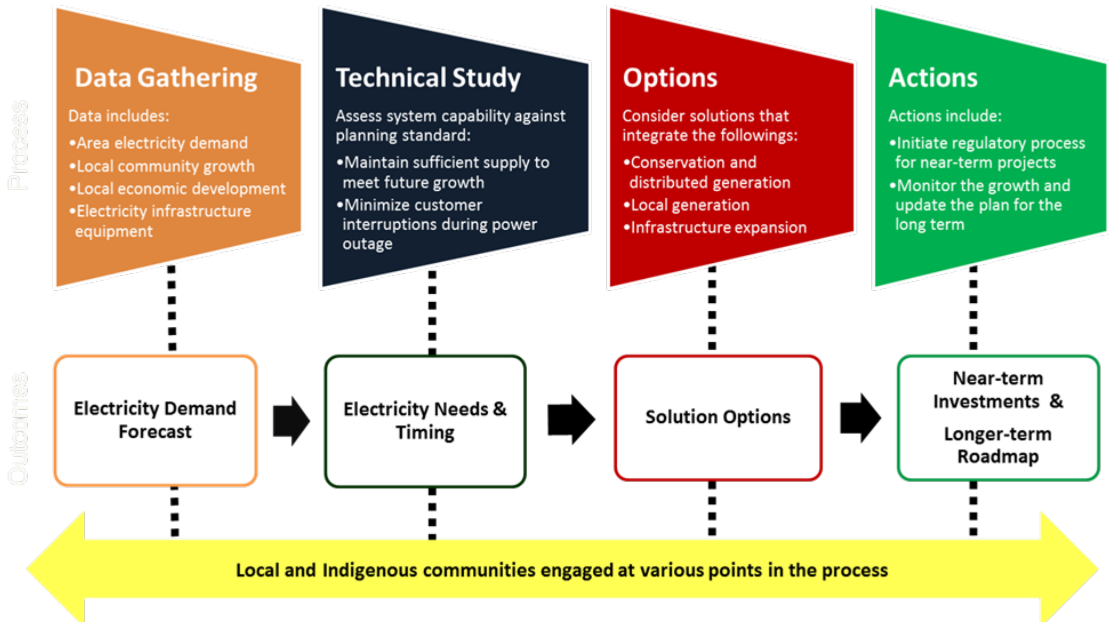
3.2 The IESO's Approach to Regional Planning

IRRPs assess electricity system needs for a region over a 20-year period. The 20-year outlook anticipates long-term trends so that near-term actions are developed within the context of a longer-term view. This enables coordination and consistency with the long-term plan, rather than simply reacting to immediate needs.

In developing an IRRP, a different approach is taken to developing the plan for the first 10 years of the plan—the near and medium term—than for the longer-term period of 10-20 years. The plan for the first 10 years is developed based on best available information on demand, conservation, and other local developments. Given the long lead time to develop electricity infrastructure, near-term electricity needs require prompt action to enable the specified solutions in a timely manner. By contrast, the long-term plan is characterized by greater forecast uncertainty and longer development lead time; as such solutions do not need to be committed to immediately. Given the potential for changing conditions and technological development, the IRRP for the long term is more directional, focusing on developing and maintaining the viability of options for the future, and continuing to monitor demand forecast scenarios.

In developing an IRRP, the IESO and the Working Group (see Figure 3-2) carry out a number of steps. These steps include electricity demand forecasts; technical studies to determine electricity needs and the timing of these needs; the development of potential options; and, a recommended plan including actions for the near and long term. Throughout this process, engagement is carried out with stakeholders and First Nation and Métis communities who may have an interest in the area. The steps of an IRRP are illustrated in Figure 3-2.

Figure 3-2: Steps in the IRRP Process



The IRRP report documents the inputs, findings and recommendations developed through the process described above, and provides recommended actions for the various entities responsible for plan implementation. Where "wires" solutions are included in the plan recommendations, the completion of the IRRP report is the trigger for the transmitter to initiate an RIP process to develop those options. Other recommendations in the IRRP may include: development of conservation, local generation, or other solutions; community engagement; or information gathering to support future iterations of the regional planning process in the region or sub-region.

3.3 Greater London Sub-region Working Group and IRRP Development

The process to develop the Greater London IRRP was initiated in September 2015 with the release of the Needs Screening report by Hydro One Transmission for the London Area Region. The subsequent Scoping Assessment report published by the IESO recommended that the needs identified for the Greater London Sub-region be further pursued through an IRRP owing to the potential for coordinated solutions.

In 2015 the Working Group was formed to develop a Terms of Reference for this IRRP, gather data, identify near- to long-term needs in the sub-region, and recommend actions to address the needs.

4. Background and Study Scope

This report presents an IRRP for the Greater London Sub-region for the 20-year period from 2015 to 2034.

To set the context for this IRRP, the scope of the planning study and the sub-region's existing electricity system are described in Section 4.1.

4.1 Study Scope

This IRRP develops and recommends preferred options to meet supply needs of the Greater London Sub-region in the near term. The plan was prepared by the IESO on behalf of the Working Group. The plan includes consideration of forecast electricity demand growth, conservation and demand management ("CDM" or "conservation") in the area, transmission and distribution system capability, relevant community plans, Feed-in Tariff ("FIT") and other generation uptake through province-wide programs.

This IRRP addresses regional needs in the Greater London Sub-region, including adequacy, security and relevant asset end-of-life consideration.

The following existing transmission facilities and geographical areas were included in the scope of this study:

- Stations—Buchanan TS, Buchanan DESN, Wonderland TS, Clarke TS, Talbot TS, Highbury TS, Nelson TS
- Transmission circuits—N21/22W, W42/43L, W5N/6NL/9L, W36/37
- In geographical terms the Greater London Sub-region roughly encompasses the City of London and parts of Middlesex County.

Figure 4-1 and Figure 4-2 show those transmission facilities and the electrical configuration of the main stations, supply sources, and transmission assets for the Greater London Sub-region.

Figure 4-1: Greater London Sub-region Transmission Facilities

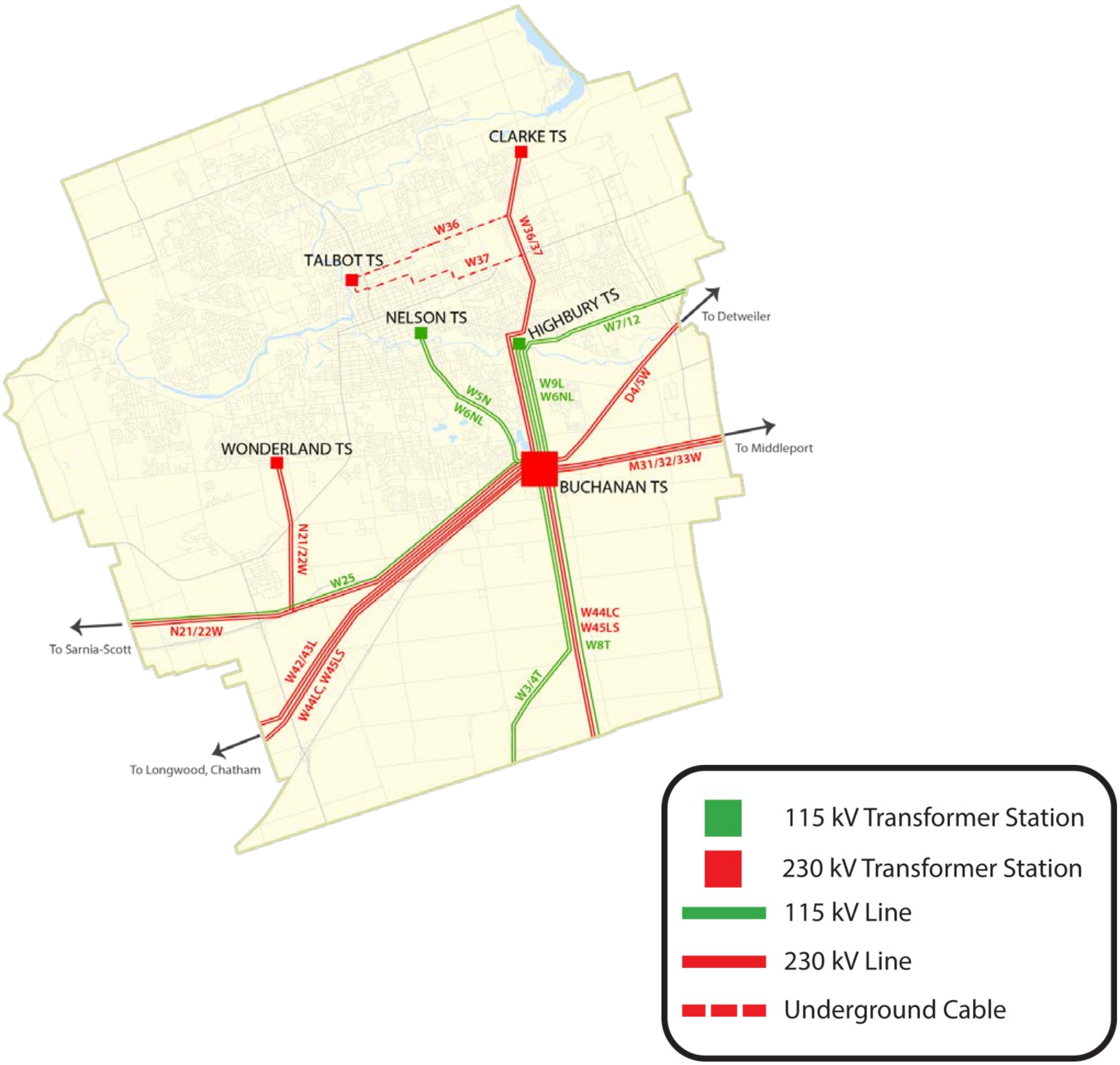
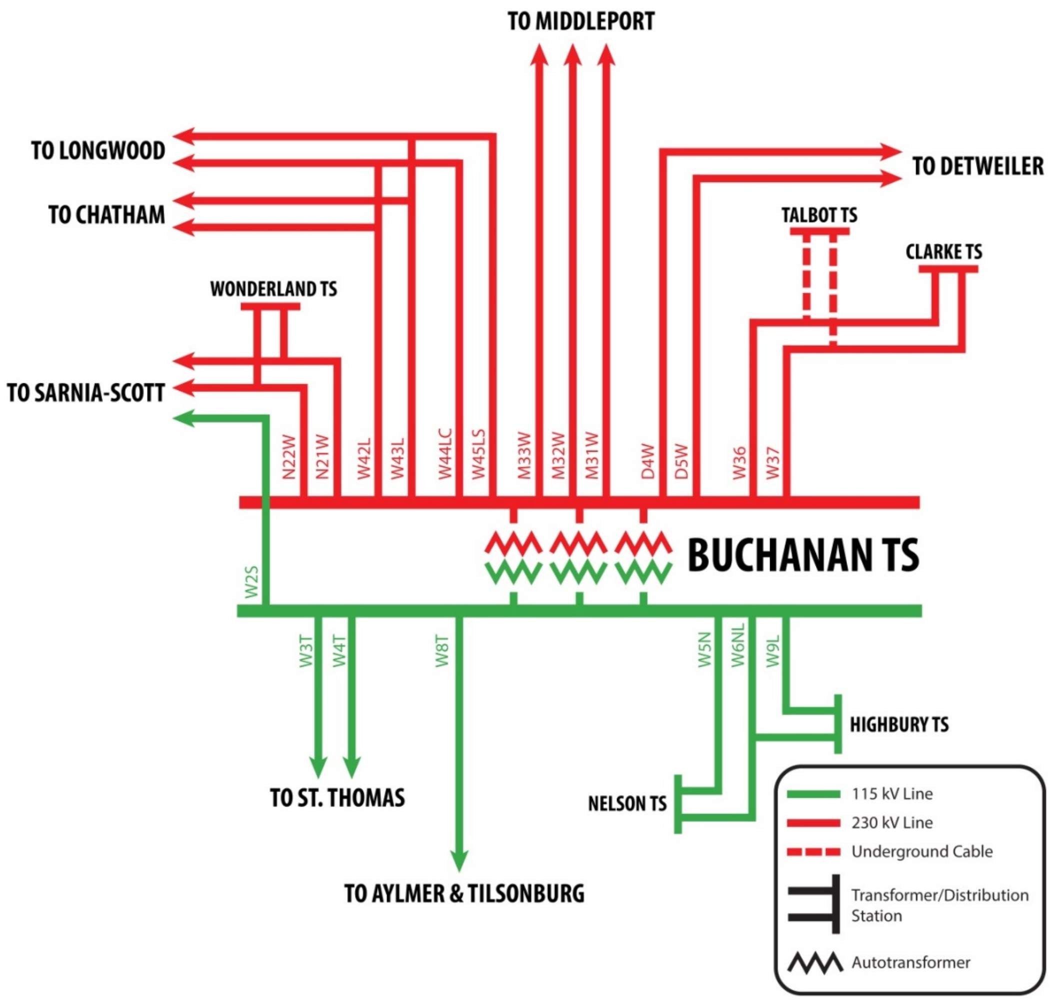


Figure 4-2: Greater London Sub-region Electrical System Configuration



The Greater London IRRP was developed by completing the following steps:

- Preparing a 20-year electricity demand forecast and establishing needs over this timeframe
- Examining the Load Meeting Capability ("LMC") and reliability of the existing transmission system supplying the Greater London Sub-region, taking into account facility ratings and performance of transmission elements, transformers, local generation, and other facilities such as reactive power devices. Needs were established by applying ORTAC
- Establishing feasible integrated alternatives to address needs, including a mix of CDM, generation, transmission and distribution facilities, and other electricity system initiatives
- Evaluating options using decision-making criteria which included: technical feasibility, cost, reliability performance, flexibility, environmental and social factors
- Developing and communicating findings, conclusions and recommendations.

5. Demand Forecast

This section outlines the forecast of electricity demand within the Greater London Sub-region. It highlights the assumptions made for peak demand load forecasts, including the contribution of conservation and DG to reducing peak demand. The resulting net demand forecast is used in assessing the electricity needs of the area over the planning horizon.

To evaluate the adequacy of the electric system, the regional planning process involves measuring the demand observed at each station for the hour of the year when overall demand in the study area is at a maximum, also called the coincident peak demand. This differs from a non-coincident peak, which is measured by summing each station's individual peak, regardless of whether the stations' peaks occur at different times.

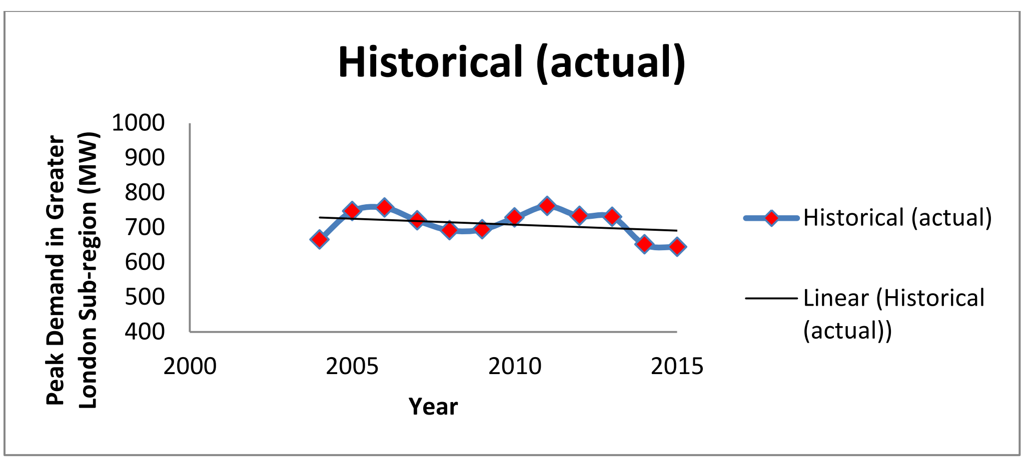
Within the Greater London Sub-region, the peak loading hour for each year typically occurs in mid-afternoon of the hottest weekday during summer, driven by the air conditioning loads of residential and commercial customers. This typically occurs on the same day as the overall provincial peak, but may occur at a different hour in the day.

Section 5.1 begins by describing the historic electricity demand trends in the sub-region from 2004 to 2015. Section 5.2 describes the demand forecast used in this study and the methodology used to develop it.

5.1 Historical Demand

The coincident peak electrical demand for the Greater London Sub-region is shown in Figure 5-1. The historical actual data (in red) shows the coincident peak demand for the year.

Figure 5-1: Historical Peak Demand in the Greater London Sub-region



The historical actuals show that demand has remained relatively stable over the past decade, with a slight dip during the recession years of 2008 and 2009, and in 2014 and 2015 due to abnormally cool summer conditions. Historical demand, as measured at the station level, already accounts for the impact of conservation measures and other demand reducing programs in-service at the time of peak. For example, verified peak demand savings from conservation programs show that approximately 11 megawatts ("MW") of peak demand was offset in 2015 across the combined London Hydro and Hydro One Distribution loads. These savings are due to conservation programs from 2011-2015 and are measured at the end-user level. Factors such as temperature at time of peak, impact of conservation programs and DG in-service at time of peak can impact historical growth trends.

5.2 Demand Forecast Methodology

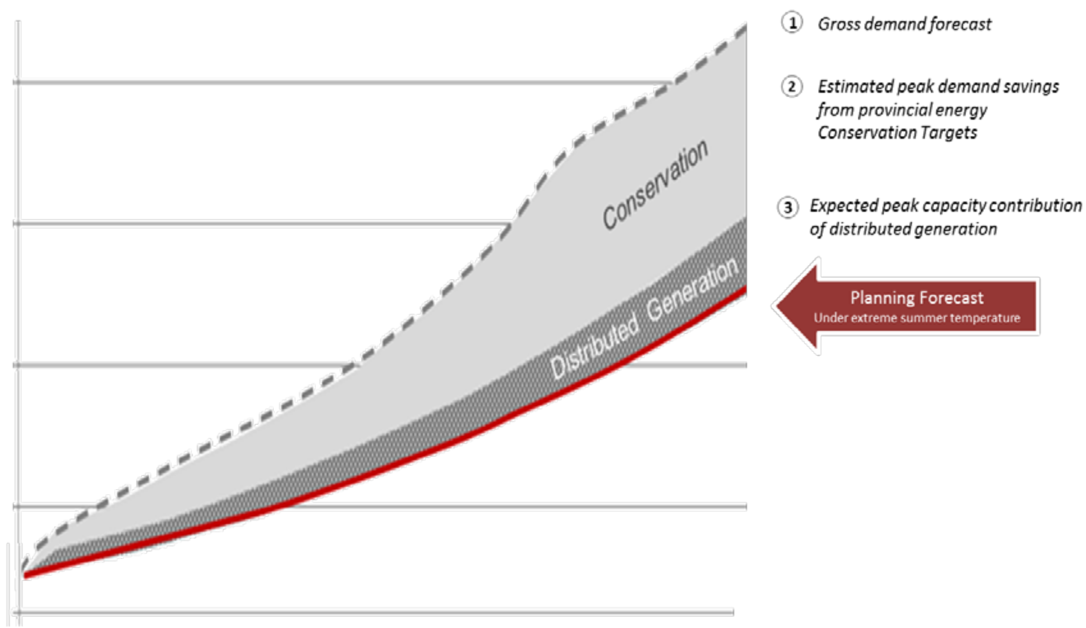
For the purpose of the IRRP, a 20-year planning forecast was developed to assess electricity supply and reliability needs at the regional level.

Regional electricity needs are driven by an area's peak demand growth exceeding the regional electricity infrastructure's supply capability. Therefore, regional planning typically focuses on growth in coincident peak demand, which is the electricity demand of individual stations that coincides with the annual peak demand of the area. It is likely that each station will reach its individual peak demand at a slightly different point in time. From the perspective of ensuring sufficient transmission supply to the entire area, it is important to consider the coincident peak, the point in time when the total demand in the area peaks. Aggregating the coincident station peak forecasts identifies the peak electricity demand that must be served by the area's transmission system.

The 20-year planning forecast is divided notionally into three timeframes. The near term (0-5 years) has the highest degree of certainty and usually requires that a decision be made to address near-term needs. The medium term (5-10 years) provides more lead time to keep various options open in order to meet needs that are up to 10 years out. The long-term forecast covers the 10-20 year period. It is used for identifying potential longer-term needs and, as necessary, considering and developing integrated solutions (including conservation, DG and major transmission upgrades). Early identification of these needs and potential solutions makes it possible to begin engagement with the local community and all levels of government long before the need is triggered. This provides the greatest opportunity to gain input on decision making, and to ensure local planning can account for new infrastructure.

The regional peak demand forecast was developed as shown in Figure 5-2. Gross demand forecasts, assuming normal-year weather conditions, were provided by the LDCs and the transmission-connected customers in the LDC's service territory. The LDC forecasts are based on growth projections included in municipal plans and customer connection requests. These forecasts were then modified to produce a planning forecast — i.e., they were adjusted to reflect the peak demand impacts of provincial conservation targets and DG contracted through provincial programs such as Feed-in Tariff ("FIT") and microFIT and to reflect extreme weather conditions. The planning forecast was then used to assess any growth-related electricity needs in the region.

Figure 5-2: Development of Demand Forecast



Using a planning forecast that is net of provincial conservation targets is consistent with the province's Conservation First policy.[4] However, it also assumes that the targets will be met and that the targets, which are energy-based, will produce corresponding local peak demand reductions. An important aspect of plan implementation will be monitoring the actual peak demand impacts of conservation programs delivered by the local LDCs and, as necessary, adapting the plan. Additional details related to the development of the demand forecast are provided in Appendix A.

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[4] Conservation First: A Renewed Vision for Energy Conservation in Ontario: http://www.energy.gov.on.ca/en/conservation-first/

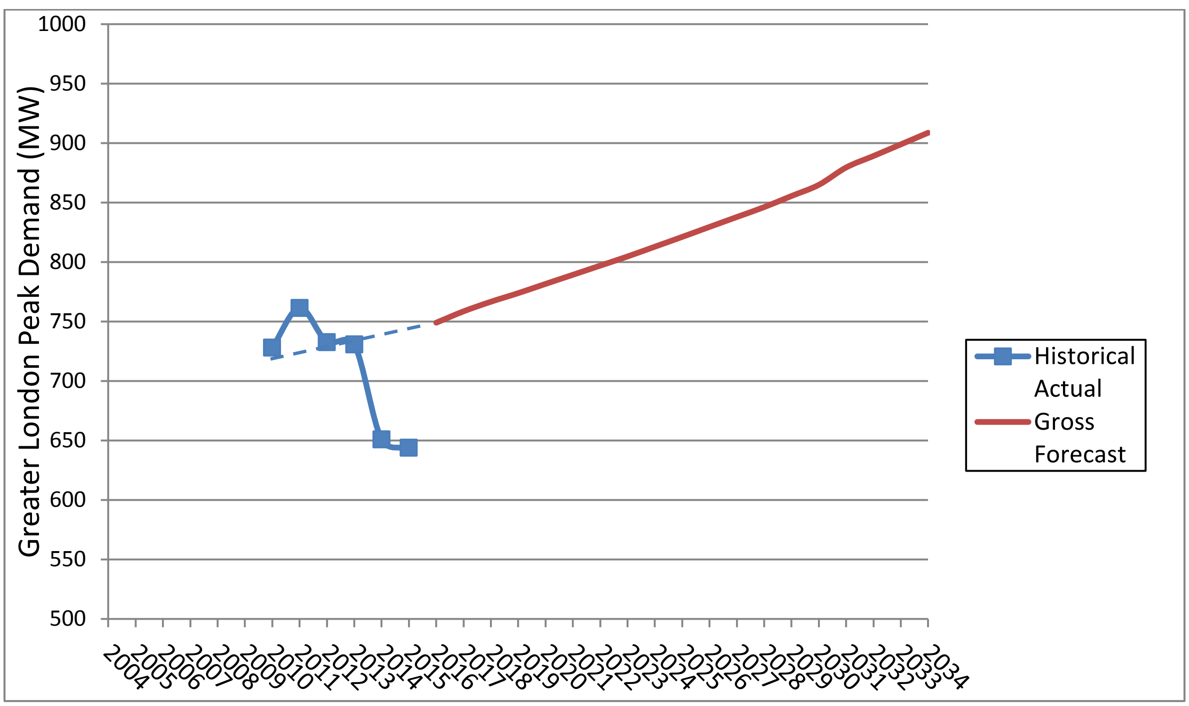
5.3 Gross Demand Forecast

Each participating LDC in the Greater London Sub-region prepared gross demand forecasts at the transformer station level or bus level for multi-bus stations. Gross demand forecasts account for increases in demand from new or intensified development, but do not account for the impact of new conservation measures such as codes and standards.

The area LDCs, London Hydro and Hydro One Distribution have the best knowledge of growth in their customer demand and these demand projections are used for the near and medium-term portions of the area forecast. Both London Hydro and Hydro One Distribution cited municipal and regional official plans as a source for input data such as growth projections provided by the City of London for population growth and residential, commercial and industrial development.

Figure 5-3 shows the gross demand forecast information provided by LDCs for the Greater London Sub-region, with historical data points provided for comparison.

Figure 5-3: Greater London Sub-region Gross Forecast



Historical actuals show that demand in the area has been stable over the past five years. As mentioned previously, the dip in 2014 and 2015 was due to abnormally cool summer conditions.

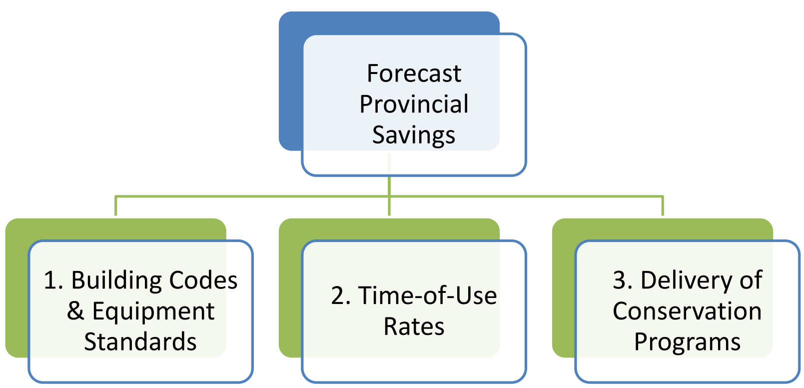
As shown in Figure 5-3, demand is expected to grow at a modest rate of approximately 1.1% annually until the end of the study period.

5.4 Conservation Assumed in the Forecast

Conservation is the first resource to be considered in planning, and procurement processes. It plays a key role in maximizing the utilization of existing infrastructure and maintaining reliable supply by keeping demand within equipment capability. Conservation is achieved through a mix of program-related activities, rate structures, and mandated efficiencies from building codes and equipment standards.

In December 2013, the Ministry of Energy released a revised Long-Term Energy Plan ("LTEP") that outlined a provincial conservation target of 30 terawatt-hours ("TWh") of energy savings by 2032. The expected peak demand savings from meeting this target were estimated for the Greater London Sub-region. To estimate the impact of the conservation savings in the sub-region, the forecast provincial savings were divided into three main categories:

Figure 5-4: Categories of Conservation Savings



1. *Savings due to Building Codes & Equipment Standards*
2. *Savings due to Time-of-Use Rate structures*
3. *Savings due to the delivery of Conservation Programs*

The impact of estimated savings for each category was further broken down for the Greater London Sub-region by the residential, commercial and industrial customer sectors. The IESO worked with the LDCs to establish a methodology to estimate the electrical demand impacts of the energy targets by the three customer sectors. This provides a better resolution of forecast conservation, as conservation potential estimates vary by sector due to different energy consumption characteristics and applicable measures.

For the Greater London Sub-region, LDCs were requested to provide a breakdown of their gross demand forecast and a breakdown of electrical demand by sector for the forecast, at each transformer station. For stations where an LDC could not provide gross load segmentation, the IESO and the LDC worked together using best available information and assumptions to derive sectoral gross demand. For example, LDC information found in the OEB's Yearbook of Electricity Distributors[5] was used to help estimate the breakdown of demand. Once sectoral gross demand at each transformer station was estimated, peak demand savings was estimated for each conservation category: codes and standards, time-of-use rates, and conservation programs. The estimates for each of the three savings groups were done separately due to their unique characteristics and available data.

Table 5-1 below shows the final estimated conservation reductions applied to the gross demand to determine the forecast net of conservation.

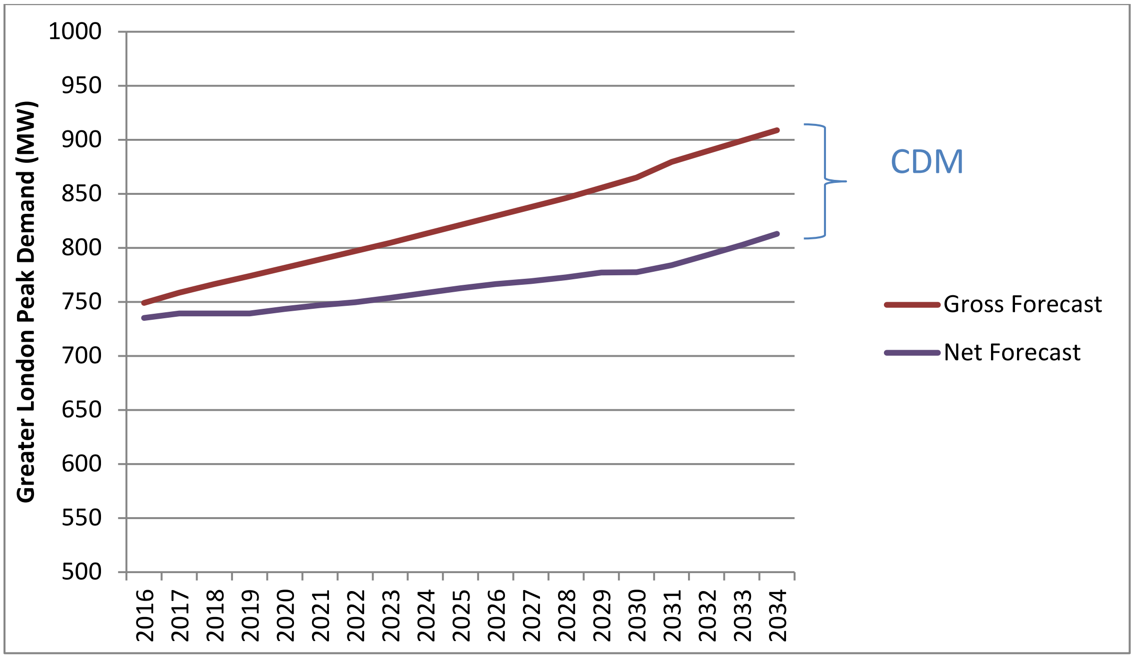
Table 5-1: Peak Demand MW Savings from 2013 LTEP Conservation Targets, Select Years

Year	2018	2020	2022	2024	2026	2028	2030	2032	2034
Savings (MW)	27	38	47	55	63	73	87	96	96

It is expected that 96 MW of peak demand will be met by conservation in the Greater London Sub-region by the end of the study period. Figure 5-5 below shows the expected impact of CDM on the gross demand forecast for the sub-region.

[5] OEB Yearbook of Electricity Distributors:
http://www.ontarioenergyboard.ca/OEB/Industry/Rules+and+Requirements/Reporting+and+Record+Keeping+Requirements/Yearbook+of+Distributors

Figure 5-5: Gross and Net Demand Forecast for the Greater London Sub-region



Additional conservation forecast details are provided in Appendix A.

5.5 Distributed Generation Assumed in the Forecast

In addition to conservation resources, DG in the Greater London Sub-region is also forecast to offset peak demand requirements. The introduction of the *Green Energy and Green Economy Act, 2009*, and the associated development of Ontario's FIT program, has increased the significance of distributed renewable generation in Ontario. This renewable generation, while intermittent in nature, contributes to meeting the electricity demands of the province.

After applying the energy conservation savings to the gross demand forecast as described above, the forecast is further reduced by the expected peak contribution from contracted, but not yet in-service, DG in the sub-region. The effects of projects that were already in-service prior to the base year of the forecast were not included as they are already embedded in the actual demand which is the starting point for the forecast. Potential future DG uptake was not included and is instead considered as an option for meeting identified needs.

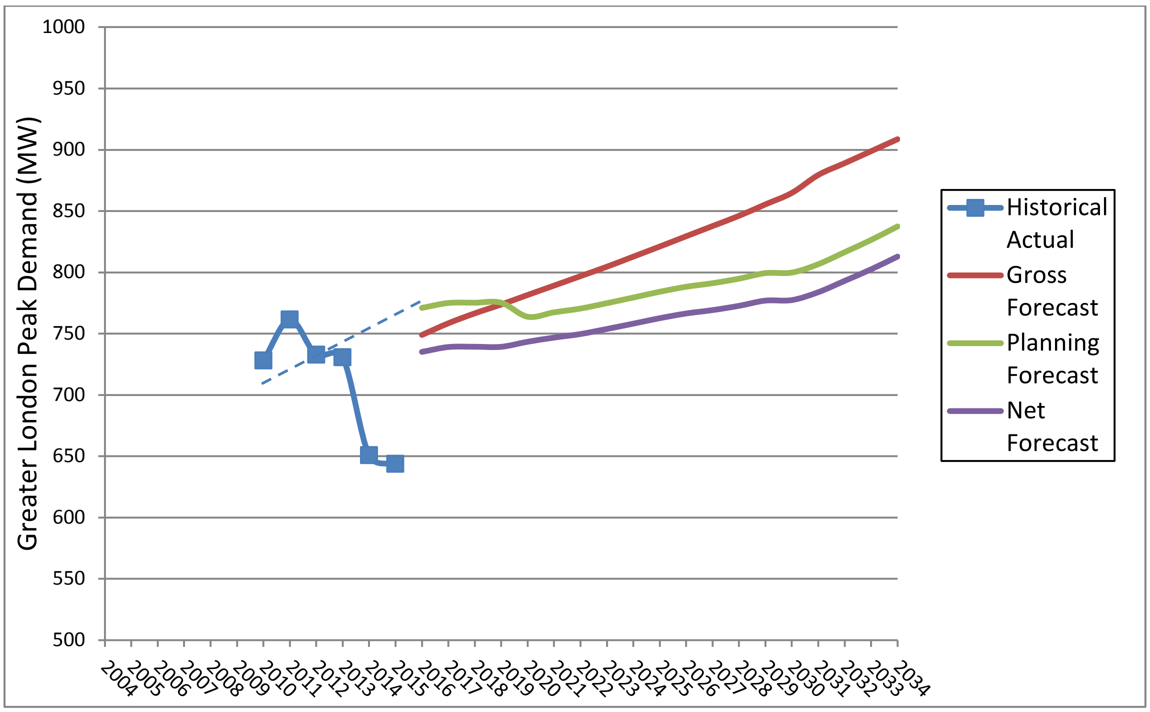
Based on the IESO contract list, new DG projects are expected to offset approximately 23 MW of peak demand within the Greater London Sub-region by 2020. Contracted DG in the area includes FIT, microFIT and CHPSOP (Combined Heat and Power Standard Offer Program), and a fuel mix of solar, bioenergy and combined heat and power.

Additional details of the regional demand reductions from province-wide DG programs and capacity contributions of different technology types are provided in Appendix A.

5.6 Planning Forecast

After taking into consideration the combined impacts of conservation and DG, a 20-year planning forecast was produced as shown in Figure 5-6.

Figure 5-6: Greater London Sub-region Planning Forecast



The figure illustrates the area's planning forecast, along with historic demand in the area and the gross and net forecasts. As described in the section above, the net forecast is produced by considering the impacts of conservation on the gross forecast. The planning forecast goes one step further by taking into account the impacts of DG and extreme weather on the net forecast. The planning forecast shows that demand in the sub-region is expected to grow modestly at an annual rate of approximately 0.5% until the end of the study period. Note that the planning forecast is adjusted to extreme weather conditions, thus is higher than the gross forecast for the first few years of the forecast and higher than the net forecast throughout the study period because of extreme weather correction. In 2020, a CHP (Combined Heat and Power) project is expected to come into service at Nelson TS, contributing to overall peak demand reduction from CDM and DG for the area.

6. Needs

In 2015, the Needs Screening and Scoping Assessment studies for the London Area Region identified capacity and restoration needs in the Greater London Sub-region. A number of stations in the sub-region were identified to be slightly above station capacity in the previous needs assessment. A restoration shortfall was also identified for the Clarke TS and Talbot TS load pockets.

As part of this IRRP, these needs were reassessed by assuming the availability of the new Nelson TS and the rebuilding of the 27.6 kV London downtown network in 2019.

6.1 Capacity

Prior to the Nelson reconfiguration project, Nelson TS stepped down voltage from 115 kV to 13.8 kV. It was the only station within the London Hydro service territory serving load at 13.8 kV while the remaining stations in the area were at 27.6 kV. The reconfiguration of Nelson TS to 27.6 kV will allow London Hydro flexibility in transferring load across its service territory at the same voltage level without the need for additional distribution level transformation. With the new Nelson TS in-service in 2019, London Hydro will be able to balance load across its entire service territory, eliminating the previously identified need for station capacity. Additionally, the London District Energy Cogeneration project (17.9 MW nameplate capacity) expected to be in-service in 2020 and connected to Nelson TS will also provide incremental local capacity to the sub-region. Therefore, the earlier identified capacity need was not studied further in this IRRP.

6.2 Load Restoration

The Needs Screening and Scoping Assessment studies also identified that supply to two load pockets in the sub-region could not be restored within the ORTAC timelines in the event of a double element outage.

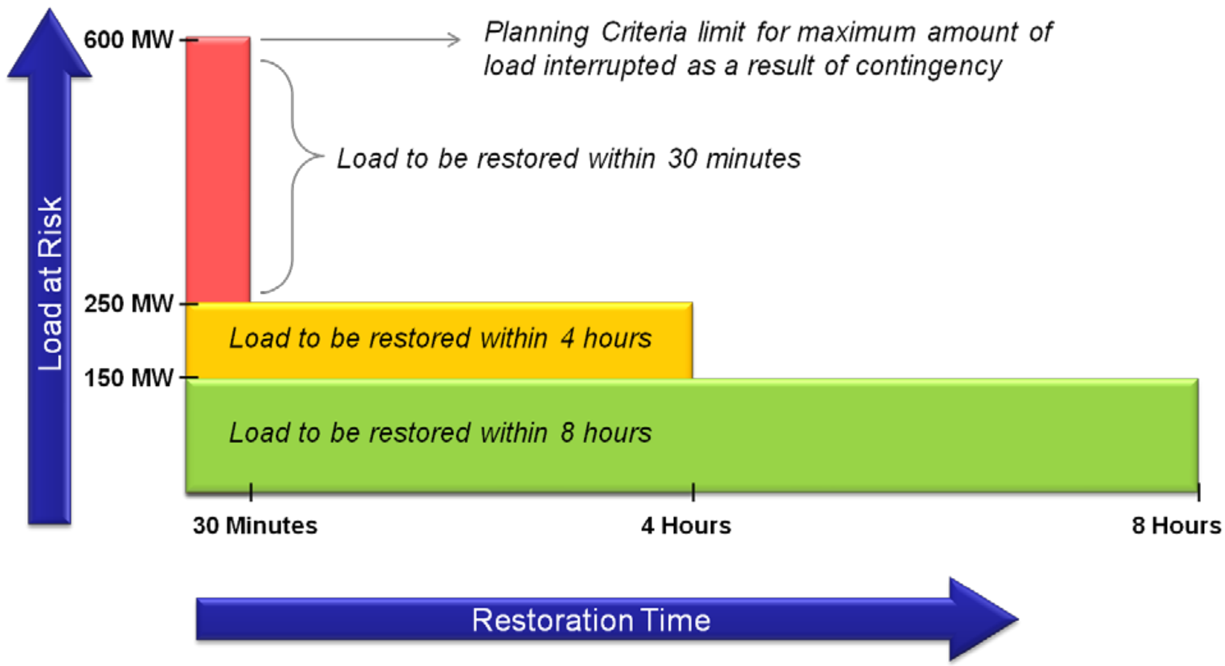
6.2.1 Assessment Methodology

The ORTAC requirement assesses the electricity system's ability to restore interrupted electricity demand after a major prolonged transmission outage within specific timelines.[6] A

[6] Relevant excerpts from the ORTAC are quoted in Appendix A

major transmission outage includes a contingency on a double-circuit tower line resulting in the loss of both circuits. The applicable ORTAC restoration criteria are summarized in Figure 6-1.

Figure 6-1: ORTAC Load Restoration Criteria



ORTAC indicates that, for the loss of two elements, any load in excess of 250 MW should be restored within 30 minutes and any load in excess of 150 MW should be restored within four hours. The criteria also indicates that any further load below 150 MW to be restored within eight hours

The following sections discuss the restoration need for the Greater London Sub-region identified during the previous studies that were part of this regional planning process.

The specific load security and restoration requirements prescribed by ORTAC are described in Appendix B.

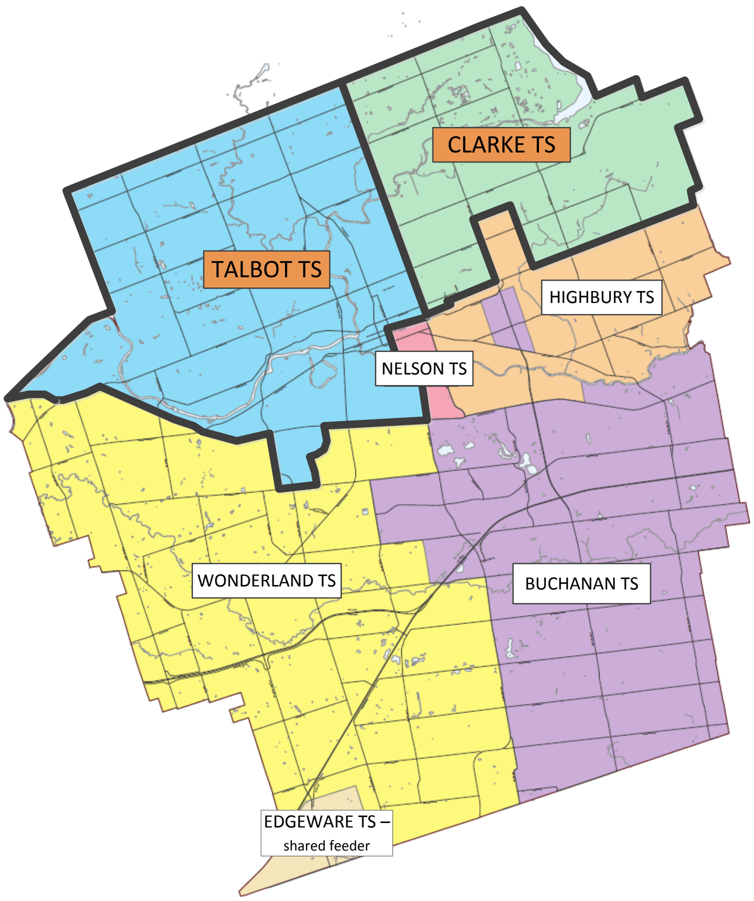
6.2.2 Restoration Needs

W36/37 pocket – Clarke TS and Talbot TS

Load supplied from two stations, Clarke TS and Talbot TS has been identified as being at risk for not meeting restoration levels as defined in ORTAC.

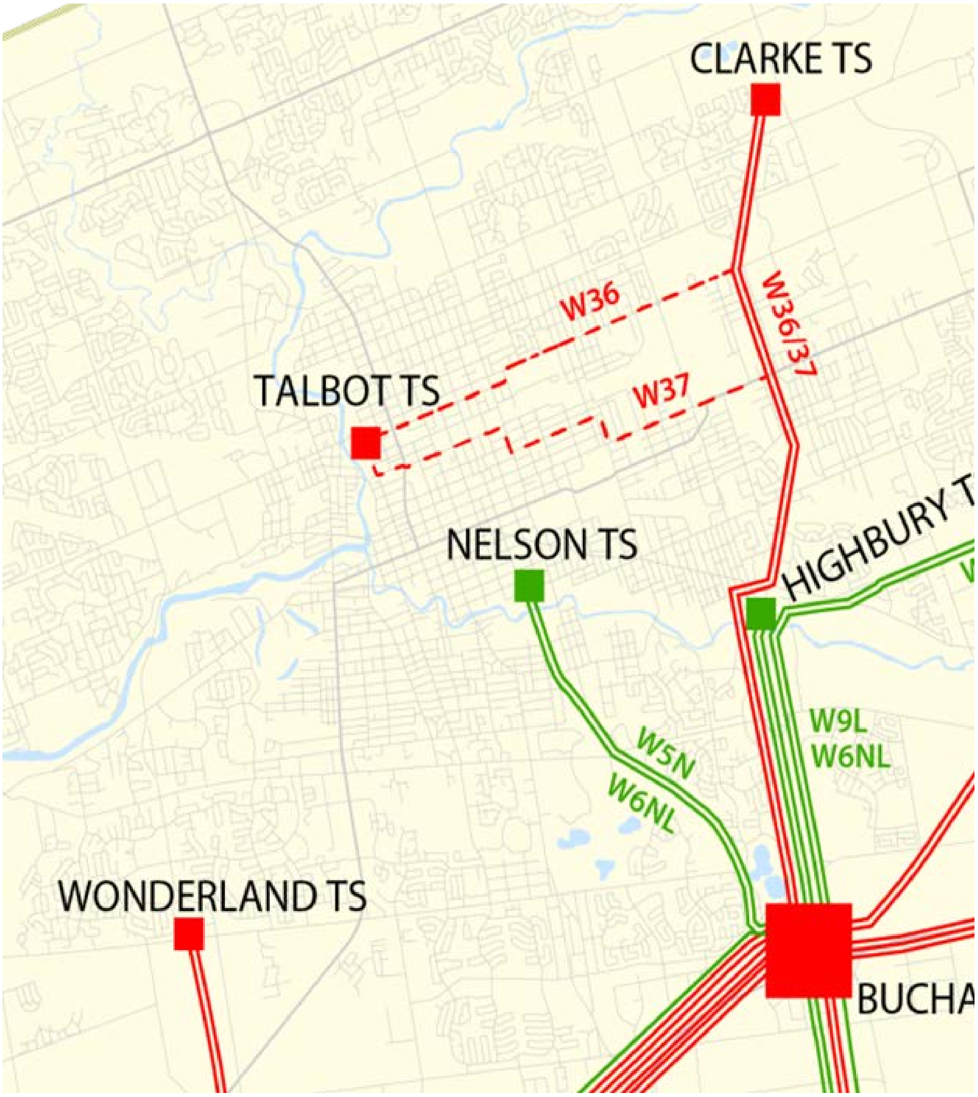
Clarke TS and Talbot TS supply approximately 90,500 customers with a total peak demand of 370 MW in London Hydro's service territory. This represents about 58% of all customers supplied by London Hydro and 52% of the total demand supplied by London Hydro. The service territory of Clarke TS and Talbot TS is shown in the Figure 6-2, while Figure 6-3 shows a high-level electrical configuration of the area.

Figure 6-2: Service Territory of Clarke TS and Talbot TS



Two overhead 230 kV circuits W36 and W37 emanating from Buchanan TS provide supply to Clarke TS and Talbot TS. Specifically, Talbot TS is supplied by two 230 kV cables (underground) tapped off the overhead W36/37 circuits. Following the loss of both overhead W36 and W37 circuits, supply would be interrupted to Clarke TS and Talbot TS. A double cable outage can also occur and the supply to Talbot TS would be interrupted in this event. The supply to Clarke TS would not be impacted by the double cable outage as there are switches that can be opened at the tap.

Figure 6-3: Transmission Configuration Supplying Clarke TS and Talbot TS



In accordance with ORTAC, all loads in excess of 250 MW must be restored within 30 minutes, and all load in excess of 150 MW within four hours, following the sudden loss of the W36/37 circuits. Given the proximity of emergency crew and equipment, all loads should be able to be restored within eight hours through conventional transmission supply in the Greater London Sub-region.

Table 6-1 below shows the total peak load at risk of interruption for select years. Specifically, it shows the amount of load that can and cannot be restored in accordance with the ORTAC 30 minute and four hour restoration timelines.

Table 6-1: Peak Load and Restoration Requirements for W36/37 Circuits (2016)

Load Pocket	2016 Net				
	Forecast	30-Min Restoration	30-Min Restoration Shortfall	4-Hour Restoration	4-Hour Restoration Shortfall
W36/37 Clarke TS and Talbot TS	394	**55**	89	**105**	139
Double Cable Outage (lose Talbot TS)	283	**50**	n/a	**77**	56

Table 6-2: Peak Load and Restoration Requirements for W36/37 (with new Nelson TS)

Load Pocket	2019 Net (Nelson TS in-service)				
	Forecast	30 min Restoration	30-minute Restoration Shortfall	4-Hour Restoration	4-Hour Restoration Shortfall
W36/37 Clarke TS and Talbot TS	370	**95**	25	**150**	71
Double Cable Outage (lose Talbot TS)	271	**80**	n/a	**107**	14

Based on information from London Hydro, up to 55 MW of load can be restored through distribution transfers within 30 minutes under the current supply arrangement and 105 MW within four hours for the loss of the overhead W36/37 circuits. The interrupted load would be transferred to Wonderland, Buchanan, and Highbury stations in the event of such an outage. With the upgrade and rebuild of Nelson TS in 2019 from 13.8 kV to 27.6 kV, Nelson TS will be able to provide additional backup capacity to support meeting the ORTAC timelines in the event of a double element 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.

In the event of an outage [7] on the underground cables serving Talbot TS, (Clarke TS would be available during this outage) the interrupted load can be transferred to Clarke TS, Highbury TS, Buchanan TS and Wonderland TS. With Nelson TS in-service in 2019, it is expected that additional load transfers can be made to the new Nelson station, providing more flexibility. It is expected that the load restoration can substantially meet the 30 minute and four hour timelines. Therefore, this cable outage restoration need was not considered further in the options stage of the IRRP.

W42/43L pocket – Buchanan DESN

Demand served from the Buchanan DESN in this sub-region is also forecast to exceed the 150 MW ORTAC 4 hour restoration timeline thresholds in 2017. Based on discussions with London Hydro, any interrupted load in excess of 150 MW due to the double element outage at Buchanan DESN can be managed by transferring loads to adjacent stations within the service area.

Therefore, the W42/43L outage restoration need was not considered further in the options stage of the IRRP. The load growth at Buchanan DESN and the related transfer capability will continue to be monitored.

6.3 Aging Infrastructure

Equipment reaching end-of-life and planned sustainment activities may have an impact on the needs assessment and option development.

Based on Hydro One's information, Table 6-3[8] below summarizes the sustainment activities planned for the Greater London Sub-region for the next five years. These planned sustainment activities have been considered in developing this plan.

[7] As indicated by Hydro One, the double cable outage can be caused by a planned outage plus a contingency. It will take a very significant period of time (a week or more) to locate the problem as these circuits are located underground, i.e., the cable experiencing contingency. However, the recall time of the cable under maintenance can likely be quicker.

[8] The table does not include sustainment plans for protection, station service, feeder breakers, and/or switches.

Table 6-3: Summary of Planned Sustainment Activities in Greater London Sub-region

Station	Sustainment Plan	Timelines
Buchanan TS	Capacitor bank replacement (SC21, SC22)	2017
Nelson TS	Rebuild of Nelson TS Converting the station low voltage to 27.6 kV	2019
Wonderland TS	Transformer Replacement (T5, GT5)	2022

6.4 Needs Summary

Load supplied from Clarke TS and Talbot TS has been identified as being at risk for not meeting restoration levels as defined in ORTAC.

The needs for the Greater London Sub-region are summarized in Table 6-4 below.

Table 6-4: Summary of Needs in Greater London Sub-region

Area	Need	Description	Need Date
W36/37	Load Restoration	Restoration shortfall for the 30 minute and 4 hour timeline defined by ORTAC with the loss of the overhead circuits	Today

7. The Plan

This section describes the alternatives considered in developing the plan for the Greater London Sub-region, provides details of and the rationale for the recommended plan, and outlines an implementation plan.

7.1 Alternatives for Meeting Restoration Need

The assumed implementation of Nelson TS in 2019, will significantly improve the restoration shortfalls for the Clarke TS and Talbot TS load pocket. The Working Group explored incremental alternatives that could mitigate the residual restoration shortfall. Additionally, the Working Group also considered solutions to maximize the use of existing electricity infrastructure and solutions that were beneficial to the LDCs.

7.1.1 Conservation

Meeting restoration criteria requires that the faulted elements (line sections) be isolated such that customer electrical demand can be restored from a reliable line section or an alternate source. Conservation is not a feasible option for addressing these types of needs.

7.1.2 Generation

The extent to which DG can restore electricity supply following a major transmission outage depends on a number of factors, such as the size of the facility, the facility's start-up time, the ramp rate, the availability of black-start capability, storage options, safety protocols and other operating procedures. Given the uncertainties and variability associated with DG resources, the Working Group agreed that DG cannot be relied upon to address restoration needs in the Greater London Sub-region.

Local generation options were also considered, as properly sited small generation could meet the restoration needs of the sub-region. Two small natural gas plants for peak supply at 50 MW could address this need, but the estimated total capital cost is $150 million. It is not cost-effective to implement localized generation plants only for improving load restoration in a local area. This option was therefore ruled out by the Working Group.

7.1.3 Transmission and Distribution

Since additional conservation and generation are not feasible options to meet the restoration shortfalls, the Working Group considered transmission and distribution options.

Transmission

One method to restore electricity supply to customers following a major outage on the transmission system is to provide backup supply. For the loss of W36/37, this requires the construction of a new 230 kV "backup" circuit to restore a portion of the interrupted load resulting from the double circuit contingency. The nearest 230 kV supply in the area is the Scott TS to Buchanan TS 230 kV circuits N21W and N22W. The new backup circuit would be approximately 10 kms long and is estimated to cost over $100 million.

This alternative was also ruled out as not being cost-effective.

Distribution

Another method to restore electricity supply to customers following a major outage on the transmission system is to execute temporary load transfers through the distribution network to unaffected neighbouring transformer stations. 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.

Implementation of automated switching devices and feeder extensions combined with the Nelson TS reconfiguration will significantly reduce the current restoration shortfall in the event of a double element outage to load supplied from Clarke and Talbot stations for a unit cost of approximately $180/kW.

7.2 Recommended Plan

For the restoration need identified in the Greater London Sub-region, the Working Group believes that switching devices and feeder extensions for a total cost of $1.8 million is a reasonable investment to substantially mitigate restoration shortfall in this area. According to ORTAC, where a restoration need is identified, "transmission customers and transmitters can consider each case separately taking into account the probability of the contingency, frequency of occurrence, length of repair time, the extent of hardship caused and cost". Additionally, these parties may also agree on higher or lower levels of reliability for technical, economic, safety and environmental reasons.

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

- Optimize the distribution system to achieve the maximum transfer capability.
- Install automated switching on existing distribution system.
- Extend existing feeders to increase distribution transfer capability.
- Continue to monitor Clarke TS and Talbot TS feeder limits and area load growth.
- London Hydro will report to the Working Group on the implementation of the distribution level solutions.

The IESO has committed to working with the affected parties to assist with any approval requirements associated with this IRRP.

Given the relatively straightforward nature and low community impact of the IRRP recommendations, a Local Advisory Committee (LAC) will not be established for the Greater London sub-region. The need for a LAC in this area will be revisited during the next regional planning cycle.

8. Long-Term Outlook

Based on the electrical demand forecasts provided by London Hydro and Hydro One Distribution, the supply capacity for the Greater London Sub-region is sufficient until the end of the study period. The recommended near- to medium-term plan is able to substantially address the restoration needs in the sub-region.

Due to the inherent uncertainty associated with producing long-term load forecasts, there is potential that additional load could materialize within the Greater London Sub-region - potentially exceeding the area's LMC. The solutions available to address this potential risk are dependent on the magnitude and pace of the longer-term electrical demand which may materialize.

If the magnitude and pace of growth in electrical demand is moderate in nature (up to 1.5% gross per year), it is likely that the needs over the next 20 years will be manageable. The anticipated needs (small in scale, spread out over many customers, and driven more by intensification than by significant new greenfield developments) are well suited to community driven solutions. This may include implementation of local distributed energy resource projects (such as small scale CHP, solar and/or storage technologies) or targeted conservation initiatives that contribute to peak demand reduction (such as DR programs). Identifying potential candidate projects or initiatives should be part of the ongoing planning and engagement process between the Working Group, local communities/municipalities, and other stakeholders in the area. The development of local Community Energy Plans also provide a valuable means for aligning the local electricity needs with municipal goals and objectives, where appropriate.

The Working Group will work with the local communities to monitor leading indicators for growth in the Greater London Sub-region. This includes monitoring changes to growth targets, the composition and location of specific customer segments (residential, commercial, industrial) and effects on electricity related to the implementation of community energy plans and/or Ontario's CCAP. If these or other factors impact service reliability or capacity of the local electricity delivery systems a new IRRP process may be initiated ahead of the 5-year planning cycle. The potential for other measures, such as incremental DG or DR programs, will continue to be discussed through engagement with local communities/municipalities, and in particular as the nature of the long-term needs, alternatives, and associated costs become clearer.

9. Engagement Activities

Keeping communities up-to-date on regional electricity planning is important. For the Greater London Sub-region IRRP, this included meetings with the City of London to share the needs identified in the regional plan and the actions being undertaken by the IESO, Hydro One Networks and London Hydro to ensure a reliable and economic level of service is maintained. The meetings also provided an opportunity to begin discussions on planning for the longer term. While no longer-term needs have been identified for the Greater London Sub-region in this planning cycle, discussions that take place now as part of community energy planning and municipal sustainability initiatives will help to inform future electricity plans and alignment of these processes.

While this dialogue for the longer term continues with municipalities and communities, and as future planning initiatives unfold, the Working Group will engage in accordance with the established community engagement principles.[9] Any updates will be posted on the dedicated London Area regional planning webpage[10] on the IESO website, and updates will be sent to all subscribers who have requested updates for this area.

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[9] http://www.ieso.ca/Pages/Participate/Regional-Planning/default.aspx

[10] http://www.ieso.ca/Pages/Ontario%27s-Power-System/Regional-Planning/London-Area/default.aspx

10. Conclusion

This report documents an IRRP that has been carried out for the Greater London area, a sub-region of the OEB's London Area planning region. The IRRP identifies electricity needs in the Greater London Sub-region over the 20-year period from 2015 to 2034, identifies a preferred distribution level solution to address the near-term needs, and lays out actions to monitor needs that may arise in the long term.

The reconfiguration of Nelson TS in the City of London's downtown and the addition of a significant amount of distributed generation are expected to provide beneficial load management capability to the area. To meet the remaining restoration shortfall need, London Hydro will consider and implement the most strategic distribution level solution(s) as noted in this study. These preferred distribution level solutions have the benefit of maximizing the use of existing infrastructure, and economically providing incremental load transfer capability to substantially address the restoration need.

The IESO will continue to provide support throughout the LDC rate approval process and assist with any regulatory matters which may arise as challenges to plan implementation.

The Greater London Sub-region Working Group will continue to meet at regular intervals to monitor developments in the sub-region and to track progress toward the plan deliverables. In the event that underlying assumptions change significantly, local plans may be revisited through an amendment, or by initiating a new regional planning cycle sooner than the OEB-mandated 5-year schedule.