Central-West Bulk Plan

April 18, 2024

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List of Abbreviations

AAR	Annual Acquistion Report
AIS	All In-Service
APO	Annual Planning Outlook
ATB	Annual Technology Baseline
BBN	Burlington Beach Niagara
BES	Buchanan East Supply
BESS	Battery Energy Storage System
BLIP/NBLIP	Buchanan-Longwood Input/Negative Buchanan-Longwood Input
BWS	Buchanan West Supply
CAD	Canadian dollars
CGS	Customer Generating Station
CKLS	Chatham-Kent/Lambton/Sarnia
DESN	Dual Element Spot Network
EV	Electric Vechicle
FABCW	Flow Away from Bruce Complex plus Wind
FALS	Flow Away from Lambton-Sarnia
FETT	Flow East to Toronto
FETL	Flow East Towards London
FIL	Flow Into Lakeshore
GH	Greenhouse
GTA	Greater Toronto Area
ICAP	Installed Capacity
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
KWCG	Kitchener/Waterloo/Cambridge/Guelph
LTE	Long Term Emergency
MECP	Ministry of Environment, Conservation and Parks
MVA	Megavoltage Ampere
MW	Megawatt
NERC	North American Electric Reliability Corporation
NPCC	Northeast Power Coordinating Council
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
OEB	Ontario Energy Board
ORTAC	Ontario Resource and Transmission Assessment Criteria
POG	Powering Ontario’s Growth
QFW	Queenston Flow West
RAS	Remedial Action Scheme
RFP	Request For Proposals
RIP	Regional Infrastructure Planning
SIA	System Impact Assessment

SS	Switching Station
STE	Short Term Emergency
TS	Transformer Station
USD	United States dollars
UVLS	Under Voltage Load Shedding
VW	Volkswagen
WOC	West of Chatham
WOL	West of London input

1 Executive Summary

This document describes the results of the Central-West Bulk Plan (the "Plan") that the Independent Electricity System Operator (IESO) has undertaken to assess the reliability of the bulk transmission system in the Central-West area. The Central-West area encompasses a large portion of southwestern Ontario, including the West, Southwest, Niagara and Bruce electricity Zones,[1] and contains all the high voltage levels that operate in Ontario: 500 kV, 230 kV and 115 kV. This area stretches roughly from the Municipality of Waterloo and City of Hamilton in the east, to the City of Sarnia and City of Windsor in the west.

This system interconnects large generators in the Sarnia-Lambton, Windsor, Bruce and Niagara areas, with existing load centres. It provides interconnection points with Michigan via Windsor and Sarnia-Lambton and borders the Niagara region, which provides interconnection points with New York. The area is also connected via the 230 kV and 500 kV system at Middleport Transformer Station (TS), within the County of Brant, to central and eastern Ontario, providing a strong path between the Central-West area and the rest of the province.

There is strong electric vehicle and battery-related manufacturing growth in Ontario that is expected to continue. The automotive sector in Ontario is growing, with significant new developments from Stellantis in Windsor to Volkswagen in St. Thomas. In addition, southwestern Ontario's population is expected to grow by two million people by the end of this decade. As a result, Ontario's electricity demand is rising, especially in the Central-West area.

The IESO's bulk planning looks at the flow of power between broad areas of the province and growth factors informed by customers and policy decisions. Thus, the focus of this Plan is confirmed economic development projects (defined as "Firm Load"), such as the Volkswagen Electric Vehicle ("EV") plant in St Thomas and spin-off loads totalling 620 MW. The other focus of this plan is 500-650 MW of potential economic development in each of the five planning regions of interest, defined as "Potential Load," which include: London Area, Kitchener/Waterloo/-Cambridge/Guelph, Windsor-Essex, Chatham-Kent/Lambton/Sarnia, and Burlington to Nanticoke regions.

The purpose of the Central-West bulk study is to:

- Ensure continued, reliable bulk supply to the London Area region, in light of the Firm Load and potential economic development in the region, including consideration of the load connection configuration as it impacts the bulk system – the focus of this Plan
- Proactively investigate a range of potential growth scenarios, across the five regions of interest[2] within southwestern Ontario, to inform future plans and possible system reinforcements if/when large new loads materialize – considered in this Plan, with further bulk or regional analysis identified, as required

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[1] Visit the IESO's zonal map illustrating the 10 electrical zones.

[2] There are seven regions in southwestern Ontario, five of which were identified as regions of interest for the Central-West Bulk Plan.

Based on the growth scenarios, and accounting for the transmission recommendations from the 2019 Windsor-Essex and 2021 West of London bulk studies that are planned to come into service between now and 2030, the following reliability issues were identified:

- Unacceptable impact to the transfer capability of the bulk transmission interface (Negative Buchanan Longwood Input [NBLIP]) as 600 MW of major economic development is added in the London Area region, on top of forecast annual growth
- Dynamic voltage support needed as 900 MW of major economic development is added in the London Area region

Considering the most cost-effective option that mitigates forecast demand growth risk, and preserves options to increase system capability in the future, the following integrated solutions are recommended to address the reliability needs for the Firm Load and accommodate Potential Load growth across the Central-West area over the long-term:

- Reconstruct the M31W circuit between Buchanan TS and the Firm Load tap point, approximately 2-5 km in length, with higher capacity double circuit towers, strung with one circuit but capable of accommodating a second circuit in the future, if/when needed. This will address the unacceptable impact to the transfer capability of the NBLIP interface as 600 MW of load is added to the London Area region.
- If more than 300 MW of Potential Load materializes in the London Area region, implement dynamic voltage devices at Ingersoll TS, as well as across the Central-West area as demand grows. Since this is a long-term need, firm recommendations are not being made at this time so as to be responsive to when and where load materializes. This will address the need as 900 MW of incremental load is added in the London Area region.

Reconstruction of the M31W circuit represents the lowest-cost option, estimated to result in a net present cost savings of approximately $4 billion -$17 billion, compared to the least-cost, non-emitting resource alternative – new wind in combination with a new battery energy storage system.

The reconstruction will relieve the unacceptable impact to the transfer capability of the NBLIP interface and allow the connection of approximately 300 MW of Potential Load in the London Area region beyond the Firm Load (i.e., 900 MW in total). It is recommended that this work be initiated immediately, assuming a five-year lead time for implementation.[3] Moreover, rebuilding the M31W circuit with double circuit towers, would preserve the option to quickly increase the transfer capability across the London Area region even further, while maintaining load security, if the Potential Load location or amount shifts from the assumptions in this Plan.

On July 10, 2023, the Ministry of Energy released the Powering Ontario's Growth (POG) report, which outlines actions to support economic growth, decarbonization, and the ongoing transformation of Ontario's electricity system. As per that report, the Ontario government is planning for a more electrified Ontario, where economic growth continues to drive new jobs and emissions continue to be reduced. The IESO's South and Central Ontario bulk planning study being initiated in 2024 will consider the objectives of the POG report across southwestern Ontario, as detailed in the IESO's 2024 Annual Planning Outlook.

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[3] Once the dynamic voltage device is installed, further load can be supplied until the next thermal limitation is reached.

Consideration of Potential Loads for the other planning regions of interest identified in the Central-West Plan will be integrated with POG objectives in the South and Central Ontario bulk planning study to better plan for potential linkages and their cumulative impact. Regional concerns identified in the Central-West Plan for the Windsor-Essex and Kitchener-Waterloo/Cambridge/Guelph regions will inform ongoing or upcoming regional planning activities.

2 Introduction

2.1 Power System Planning in Ontario

The Independent Electricity System Operator (IESO) is responsible for conducting independent planning for electricity generation, demand management, conservation and transmission in the Province of Ontario.[4] In carrying out this mandate, the IESO undertakes planning activities to ensure that the province has, and will continue to have, an adequate and reliable supply of resources and transmission to meet Ontario's electricity needs. The IESO's planning generally consists of regional planning and bulk system planning. These are two separate but inter-related planning activities. Regional planning is carried out according to a regional planning process endorsed by the Ontario Energy Board (OEB). Regional planning produces plans that address system issues that are local in nature, within 21 planning regions covering the province. Bulk system planning is carried out by the IESO to address system issues that are more provincial in nature, such as the province-wide need for generation capacity, and transmission system solutions to enable transporting power reliably and economically across the province. The IESO also conducts regulatory compliance studies and completes reporting requirements, such as those set out in the North American Electric Reliability Corporation (NERC) reliability standards and the Northeast Power Coordinating Council (NPCC) criteria.

In February 2021, the bulk power system planning process was formalized through the High-Level Design Overview, to make the design and implementation of plans more consistent, timely, and transparent. As part of that process, the IESO utilizes the Annual Planning Outlook (APO) as the reporting vehicle that summarizes the forecasted bulk system reliability issues over the next 20 years. Since 2022, the APO describes how the IESO plans to address each bulk issue, either through an individual bulk system study or resource procurements. System issues reported in the APO that require a bulk system study are referenced in the APO Schedule of Planning Activities, which communicates the timelines for initiating bulk system studies.

2.2 Central-West Bulk Plan

As identified in the 2022 APO's Schedule of Planning Activities, this study was originally scheduled to begin in 2024. However, due to the recent Volkswagen electric vehicle (EV) plant announcement in St. Thomas and rapidly evolving economic development opportunities across southwestern Ontario, this work was advanced to start in mid-2023.

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[4] The IESO's objects, including for power system planning, are as set out in the Electricity Act, 1998.

The objectives of this Plan are to:

- Ensure continued, reliable bulk supply to the London Area region, in light of the Firm Load and potential economic development in the region, including consideration of the load connection configuration as it impacts the bulk system[5] – the focus of this Plan
- Proactively investigate a range of potential growth scenarios, across the five regions of interest within southwestern Ontario, to inform future plans and possible system reinforcements if/when large new loads materialize – considered in this Plan, with further bulk or regional analysis identified, as required

Study scope and objectives are in response to customers, policy decisions, economic development, and governmental direction. This Plan summarizes the results of the bulk assessment, focused on the first objective, as well as any bulk impacts of large new loads in other areas within the Central-West area. Remaining studies, currently planned to be incorporated into a new South and Central Ontario bulk study, will complete the second objective, while being responsive to policy decisions and economic development as the sector evolves.

The Central-West area encompasses a large portion of southwestern Ontario, including the West and Southwest electricity Zones, which is a system that contains all high voltage levels that operate in Ontario: 500 kV, 230 kV and 115 kV. This area stretches roughly from the Municipality of Waterloo and City of Hamilton in the east, to the City of Sarnia and City of Windsor in the west, as illustrated in **Figure 1**.

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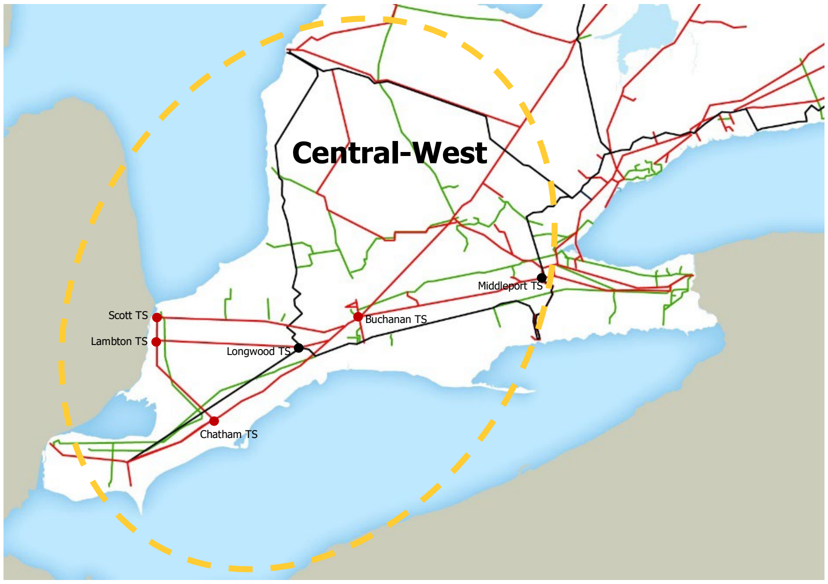
[5] The connection facilities, including design and location of the customer supply station, are out of scope of bulk planning. This is determined by the customer and connecting transmitter, Hydro One in this case, and taken as inputs into this Plan. However, as detailed in Appendix C, this Plan did consider which bulk circuits that customer connection should tap onto, since there were broader bulk implications for growth in general.

Figure 1 | Geographic Map Illustrating Central-West Area



This system interconnects large generators in the Sarnia-Lambton, Windsor, Bruce and Niagara areas with existing load centres, and encompasses the growing industrial sector in and around London and across southwestern Ontario. It provides four interconnection points with Michigan's power system via Windsor and Sarnia-Lambton, and borders the Niagara region, which provides interconnection points with New York.

The bulk of the electrical supply to the London Area region is transmitted into southwestern Ontario through 230 kV circuits from Buchanan Transformer Station (TS) to Scott TS, Lambton TS, and Chatham Switching Station (SS), carrying Sarnia-Lambton generation; 500 kV circuits from the Bruce complex; and the 500 kV and 230 kV network emanating from Middleport TS to provide supply from other provincial resources. Over the last decade, prevailing power flows on the bulk system have been east towards Toronto, from gas generation located largely in Sarnia-Lambton, as well as nuclear generation in Bruce. However, with load changes across southwestern Ontario, bi-directional flow is expected in the future as new load connects.

This Plan is organized into the following sections:

- Section 2, "Introduction," provides an overview of power system planning and the purpose of the Central-West Bulk Plan
- Section 3, "Background and Scope," provides background on the areas of interest within the Central-West area, specifically the London Area, Windsor-Essex, Chatham-Kent/Lambton/Sarnia, Kitchener/Waterloo/Cambridge/Guelph, and Burlington to Nanticoke regions
- Section 4, "Demand Forecasts," details the demand forecast assumptions
- Section 5, "Existing Supply to the Broader Central-West Area and London Area Region," presents the existing supply sources and resource scenarios considered in the bulk study
- Section 6, "Needs Determination," provides the results of the bulk studies, transfer capabilities and congestion considerations
- Section 7, "Options Evaluation and Recommendations," analyzes the transmission and resource alternatives considered to meet the supply capacity needs
- Section 8, "Community and Stakeholder Engagement," goes over the engagement activities to date and moving forward for the Central-West area

- Section 9, “Conclusions and Recommendations,” summarizes the recommendations for the Central-West area and implications on subsequent bulk and regional studies
- Appendix A: Application of Criteria outlines the planning standards applied, and contingencies considered
- Appendix B: Economic Assessment Assumptions details the options and assumptions associated with the cost comparison for the alternatives
- Appendix C: Connection Configuration Requirement presents the Firm Load connection configuration requirement

3 Background and Scope

3.1 Background

This Plan reviews the Central-West bulk transmission system to identify bulk system needs from a planning perspective, encompassing the area roughly from the Municipality of Waterloo and City of Hamilton in the east, to the City of Sarnia and City of Windsor in the west. The scope of this study is limited to the bulk system, so while the footprint of the Central-West area encompasses more than what is listed below, only elements that would result in bulk limitations are included. Generally, this includes the 500 kV and 230 kV systems, and excludes the 115 kV system and radial lines. Load connection details and associated local concerns are also out of scope. The connection facilities for confirmed loads, including design and location of the customer supply station, are determined by the customer and connecting transmitter and taken as inputs into this study. However, bulk implications of the load connection were considered (i.e., optimal configuration of the load connection line to the bulk system). In addition, certain additional elements are excluded from the scope of this Plan in cases where a previous study was recently completed and reinforcements have been recommended (e.g., the Lambton to Chatham circuits). For example, anything west of Chatham SS, would be considered a regional need, to be addressed through ongoing regional planning.

The following infrastructure was monitored as part of the scope of this Plan:

- **Transmission Stations:** Buchanan TS, Detweiler TS, Middleport TS, Ingersoll TS, Karn TS, Preston TS, Burlington TS, Beach TS, Longwood TS, Nanticoke TS, Lakeshore TS, and Edgeware TS
- **Transmission Circuits:**
    - **230 kV:** M31W, M32W, M33W, D4W, D5W, M20D, M21D, M27B, M28B, Q23BM, Q25BM, M34H, Q24HM, Q29HM, B18H, B20H, W44LC, W45LS, W42L, W43L, N1M, N5M, N6M, K40M, N20K, S39M, N37S, B20H, B18H, M34H, N21W, N22W, L24L, L26L, D6V, D7V, T36B, T37B, T38B, T39B.
    - **500 kV:** N582L, N581M, N582M, new Longwood to Lakeshore single circuit (LxH), M585M, V586M.

The Central-West area encompasses several electrical planning regions, five of which have been identified as regions of interest, as described in more detail below.

3.2 Regions of Interest

In response to customers, policy decisions, economic development, and governmental direction, five planning regions[6] were identified as requiring proactive investigation to understand the impact of economic development on the bulk system capability, as well as to inform future plans and potential system reinforcements if/when large new loads materialize. These planning regions include the London Area, Kitchener/Waterloo/Cambridge/Guelph (KWCG), Windsor-Essex, Chatham-Kent/Lambton/Sarnia (CKLS), and Burlington to Nanticoke regions, as illustrated in **Figure 2**. Note that, the electricity planning regions are defined by electricity infrastructure boundaries, not municipal boundaries.

Each of the regions and their electricity growth drivers are described in the following subsections.

Figure 2 | Geographic Map of Five Regions of Interest for the Central-West Study

The other two regions in southwest Ontario – Niagara and Greater Bruce/Huron – were not included in the scope of this study, either because recent plans were completed that considered additional load beyond the regional reference forecast, or they are a net source of electricity. For the Niagara region, an Integrated Regional Resource Plan (IRRP) was recently completed in 2022, which set out a plan that enables approximately 140 MW of additional supply to Port Colborne/Welland by 2028, based on recommended reinforcements (converting Crowland TS to a new 230 kV station, supplied by new 230 kV double circuit lines from Q24HM and Q29HM).[7] Additional load beyond 140 MW could also potentially be supplied from the new 230 kV circuits pending further studies, if required. Conversely, the Greater Bruce/Huron region was not included, as no supply transfer needs were identified in the recently completed regional plan, and the region is a large net source of electricity for the province with over 7,000 MW of generation.[8]

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[6] Planning regions are the IESO-defined 21 electricity planning regions. Refer to the Regional Planning website for more details: https://www.ieso.ca/en/Get-Involved/Regional-Planning/About-Regional-Planning/Overview

[7] Refer to the 2022 Niagara IRRP, https://www.ieso.ca/-/media/Files/IESO/Document-Library/engage/Niagara/niagara-IRRP-Report.ashx

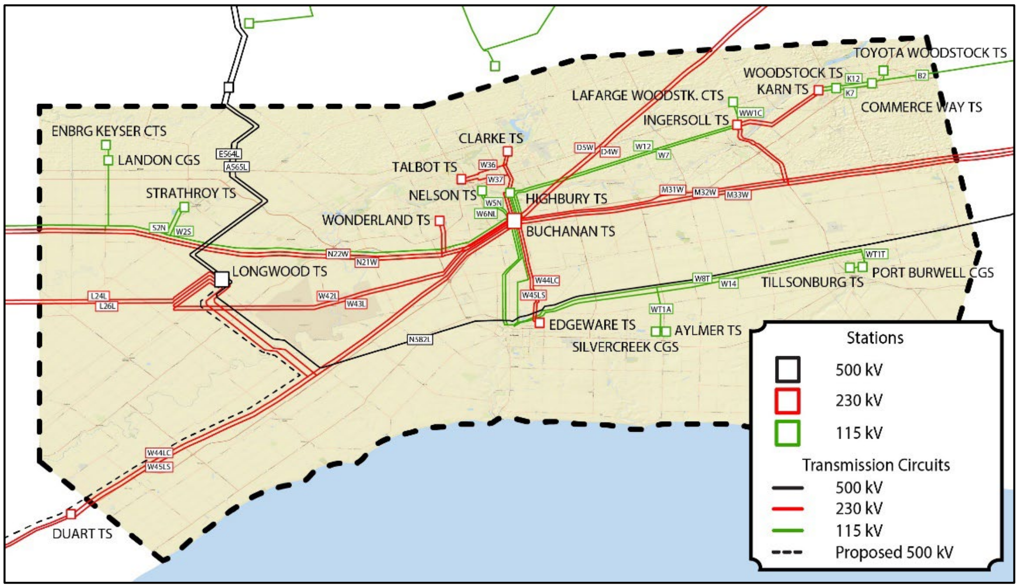
[8] Refer to the 2021 Southern Huron-Perth IRRP, https://www.ieso.ca/-/media/Files/IESO/Document-Library/regional-planning/Greater-Bruce-Huron/Southern-Huron-Perth-IRRP-20210916.ashx

3.2.1 London Area

The London Area region is located in southwestern Ontario and includes the municipalities of Oxford County, Middlesex County, Elgin County, City of London, City of Woodstock, and City of St. Thomas. Regional planning for the London Area region has historically been divided into five sub-regions: Greater London, Alymer-Tillsonburg, Strathroy, Woodstock, and St. Thomas.

The electricity infrastructure supplying the London Area region is shown in **Figure 3**. The region is supplied from 115 kV and 230 kV transmission lines and stations that connect at the Buchanan and Longwood transformer stations. The 500/230 kV auto-transformers at Longwood TS and the 230/115 kV auto-transformers at Buchanan TS and Karn TS provide the major source of supply to the area.

Figure 3 | Overview of London Area Region



This region has three transmission-connected generating stations, including a 40 MW windfarm connected to the 115 kV circuit west of Strathroy TS, a 99 MW windfarm connected to the 115 kV circuit near Tillsonburg TS, and a 10 MW solar generator connected to the 115 kV circuit near Aylmer TS.

The London region is one of the fastest growing urban centres in Canada, with its population increasing by 10 per cent between 2016 and 2021, with newcomers from other countries, as well as other Canadian cities.[9] With large industrial facilities both existing and planned in the area, including those for Volkswagen, Amazon and Maple Leaf Foods, employment opportunities and housing starts are projected to continue to grow.

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[9] https://www12.statcan.gc.ca/census-recensement/2021/as-sa/98-200-x/2021001/98-200-x2021001-eng.cfm

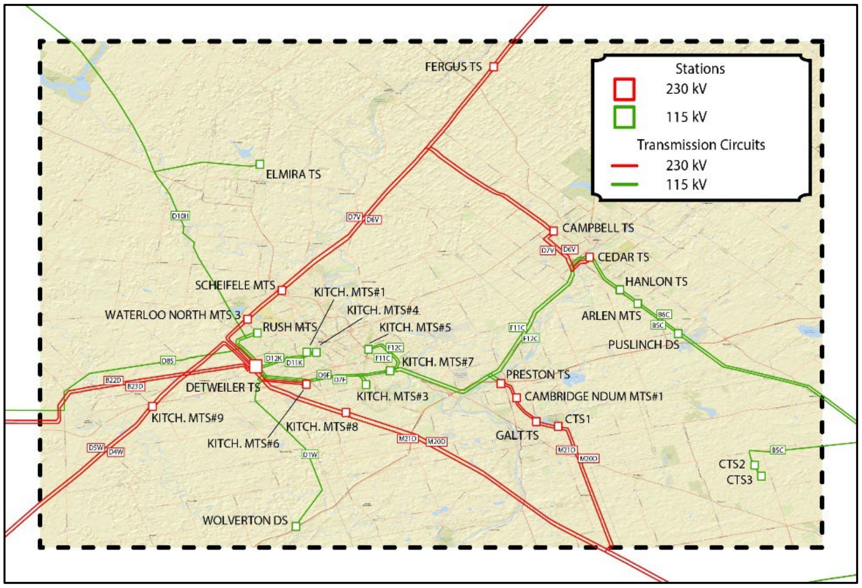
The second cycle of the London Area regional planning process proceeded directly to a Regional Infrastructure Plan (RIP), which was prepared by Hydro One in August 2022. At the time, the full regional process, or IRRP, was determined not to be required because no regional needs were identified. Instead, the load restoration need was assessed as part of Local Planning by Hydro One and the relevant Local Distribution Company.

3.2.2 Kitchener/Waterloo/Cambridge/Guelph

The KWCG region is located in southwestern Ontario and encompasses the Region of Waterloo, the cities of Kitchener, Waterloo, Cambridge and Guelph, and the townships of Wellesley, Woolwich, Wilmot, North Dumfries, and portions of Perth and Oxford. Wellington County and the municipalities of Blandford-Blenheim, Centre Wellington, Guelph/Eramosa, and Puslinch are also included in the region. The KWCG region is summer-peaking and is served via 230 kV and 115 kV circuits originating from Detweiler TS and Burlington TS, and by load stations that tap double circuit 230 kV lines connecting to Detweiler from Orangeville (D6V and D7V), from Middleport (M20D and M21D) and from Buchanan (D4W and D5W). There are no transmission-connected resources in this area.

An overview of the KWCG region and the location of the electrical infrastructure are shown in **Figure 4**.

Figure 4 | Overview of the KWCG Region



The KWCG region electricity demand is a mix of residential, commercial, and industrial loads, encompassing diverse economic activities ranging from educational institutions to automobile manufacturing. While the industrial and commercial sectors are the largest consumers of electricity, high energy-consuming end uses such as air conditioning also play a significant role in contributing to peak electricity demand. The historical summer peak demand has fluctuated between 1,200 MW to 1,350 MW in recent years.

There are multiple factors affecting electricity demand within the KWCG region. The first factor driving electricity demand is population growth. In response to the Ontario's A Place to Grow plan, the Region of Waterloo completed the first phase of its review of the Regional Official Plan in 2022, which includes forecast population and employment growth. The Region of Waterloo estimated that the population will increase from 232,200 in 2006 to 341,500 in 2029, and that employment will increase from 106,100 in 2006 to 139,700 in 2029. The growth in population and employment will drive electricity demand for the next 20 years.

The second factor affecting electricity demand is the change in the industrial sector. The Region of Waterloo is internationally known for its leading-edge technology and advanced manufacturing industries, innovative educational institutions, vibrant agricultural communities, and the historically significant Grand River. The City of Kitchener is experiencing a conversion from being a manufacturing-oriented economy to a more diversified and balanced economy. Kitchener-Wilmot Hydro lost its top three load customers in the past 10 years. Meanwhile, more customers with smaller demand emerged in the industrial and commercial sectors.

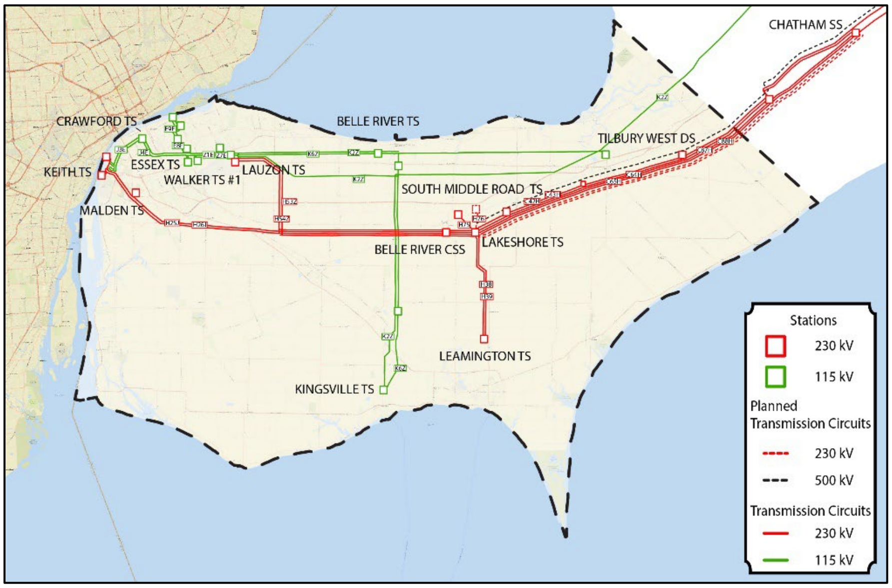
The third factor affecting electricity demand growth is the Region of Waterloo's Regional Official Plan. To support the provincial policy in the *Places to Grow Act*, as well as the city's efforts to intensify the Kitchener downtown area, the Region of Waterloo installed a light rail transit system between Waterloo and Kitchener, with a plan to extend the rail system to Cambridge. The installation of the light rail transit is spurring development along the train route in both the residential and commercial sectors.

The fourth factor affecting electricity demand is the rising awareness of renewable energy generation development, and conservation and demand management. As directed by the OEB, Kitchener-Wilmot Hydro is currently participating in multiple provincial renewable energy programs and conservation and demand management programs, which help control and reduce the electricity demand. Time-of-Use is also shifting demand and conserving energy as customers manage their electricity use and control their costs.

3.2.3 Windsor-Essex

The Windsor-Essex region is the southernmost portion of Ontario, extending southwest from the Municipality of Chatham-Kent to the City of Windsor. Electricity to Windsor-Essex is supplied from the rest of the province through two 230 kV double circuits and two 115 kV single circuits. The main 230 kV transmission corridor in the region connects with the rest of the province at Chatham SS in the Municipality of Chatham-Kent, as shown in **Figure 5**.

Figure 5 | Overview of Windsor-Essex Region



Electricity demand in the region is growing at a rapid pace, as agriculture and manufacturing continue to develop. The Kingsville-Leamington area within the Windsor-Essex region is home to North America’s largest concentration of greenhouse vegetable production. Growth has been driven by strong indoor agricultural growth, mainly vegetable greenhouses. This also includes, in part, cannabis, specifically through existing greenhouses switching to lit indoor facilities, expansion of greenhouse facilities, and supplemental load to support the agricultural sector. In addition, Windsor remains the country’s manufacturing and automotive powerhouse, with significant recent investments in electric vehicle battery manufacturing. While agriculture has been driving electricity demand growth and needs in the region over the last few years, especially in winter, economic development across the region, electrification, and local climate action plans are expected to be key factors for future electricity needs.

Electricity planning in Ontario typically occurs on a cyclical basis. However, due to the rapidly growing agricultural sector, planning in southwestern Ontario has been occurring on a continuum over the last five years, with no signs of slowing down. The 2019 Windsor-Essex bulk study occurred in parallel with the 2019 Windsor-Essex IRRP, focused on increasing the overall transfer capability of the bulk transmission system west of Chatham in order to reliably supply the forecast load growth in the Kingsville-Leamington area and Windsor-Essex region. In 2021, the West of London (WOL) bulk plan considered the area from outside the western edge of the City of London, to the City of Sarnia in the northwest, and to the City of Windsor in the west. The WOL bulk plan looked to address remaining bulk transmission system constraints east of Chatham, ensure adequate supply to the larger WOL area, and, given the expiry of generation contracts in the area, identify any transmission constraints limiting the ability of supply resources and imports within WOL to meet provincial needs. In tandem, the 2022 Windsor-Essex Addendum was undertaken to address remaining local needs in Kingsville and Leamington.

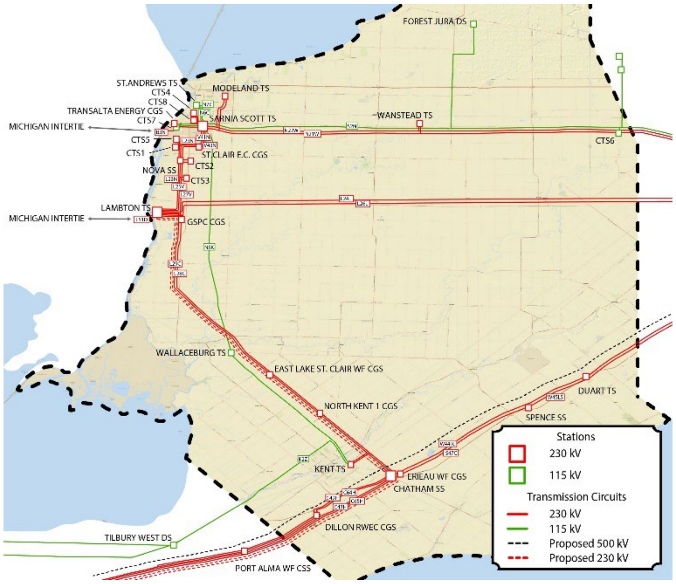
As a result, a significant number of recommendations have been made to date, ranging from transmission (such as new supply stations, transmission lines and a switching station) and local and zonal generation requirements, to non-wires recommendations (including a targeted call for indoor agriculture projects and efficiency incentives). The next cycle of regional planning is ongoing, with an IRRP that began in May 2023. The IRRP complements this Central-West Bulk Plan by focusing on regional concerns, including supply within the region, the evolving economic development opportunities in the Windsor area and agricultural load in the Kingsville-Leamington area, as well as assessing the need for a transmission reinforcement between Lakeshore TS and Windsor.

3.2.4 Chatham-Kent/Lambton/Sarnia

The Chatham-Kent/Lambton/Sarnia region is located west of the City of London and east of Essex County, and includes the municipalities of Lambton Shores and Chatham-Kent, the townships of Petrolia, Plympton-Wyoming, Brooke-Alvinston, Dawn-Euphemia, Enniskillen, St. Clair, Warwick, and Villages of Oil Springs and Point Edward. Portions of Huron County (Municipality of South Huron) and Elgin County (Municipality of West Elgin) are also included in the region. This region also has a number of First Nations and Métis Nation of Ontario community councils.

An overview of the Chatham-Kent/Lambton/Sarnia region and the location of the electrical infrastructure are shown in **Figure 6**.

Figure 6 | Overview of the Chatham-Kent/Lambton/Sarnia Region



This region is summer-peaking, however, forecast agricultural load growth in the Municipality of Chatham-Kent is winter-peaking. The region is currently supplied from a network of 115 kV and 230 kV transmission lines and stations, from the western edge of the City of London, to the City of Sarnia in the northwest, and the Municipality of Chatham-Kent in the southwest.

The bulk of supply in the region is transmitted from the 230 kV circuits between Lambton TS, Scott TS, and Chatham SS in the area, connected to the broader provincial system through Longwood TS and Buchanan TS in the east (N21W, N22W, L24L, L26L, W44LC and W45LS). It is also connected to the Windsor-Essex region in the west, through 230 kV circuits at Chatham. There is a significant amount of supply resources in Sarnia-Lambton, strategically located near the Dawn gas supply hub, as well as three of the four interconnections between Ontario and Michigan (B3N, L4D and L51D). This area also includes large petro-chemical industrial loads in Sarnia-Lambton, much of which are interdependent with the combined heat and power generators. There is approximately 2,300 MW of gas generation in the region, strategically located near the Dawn gas supply hub.

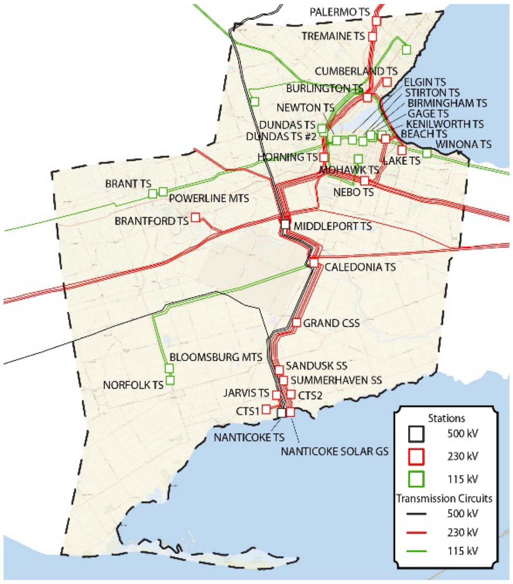
Growth in the Chatham-Kent/Lambton/Sarnia region has been driven by population growth, agricultural development in the Dresden area, and industrial growth in Sarnia-Lambton. The Municipality of Chatham-Kent was an early adopter and is a large supporter of renewable energy in Ontario. The County of Lambton and City of Sarnia house over 190,000 people, with electricity demand largely driven by the hub of traditional petro-chemical industrial loads and the emerging bio-industrial and clean energy economy. Since Sarnia-Lambton houses a large concentration of refineries and chemical producers that could switch from using high- to low-carbon hydrogen, the municipality is also positioning itself to play a key role in Ontario’s hydrogen strategy.

3.2.5 Burlington to Nanticoke

The Burlington to Nanticoke region is located in southwestern Ontario and includes all or part of the following Counties and Districts: City of Hamilton, Brant County, the City of Brantford, Haldimand County, Norfolk County, and the Regional Municipality of Halton. The region includes several Indigenous communities that are located in or near the region.

An overview of the Burlington to Nanticoke region and the location of the electrical infrastructure are shown in **Figure 7**.

Figure 7 | Overview of the Burlington to Nanticoke Region



The Burlington to Nanticoke region is expected to have both organic growth and economic development projects across the region, along with strong industrial growth and interest in ensuring electricity infrastructure can accommodate economic development. In addition, significant community energy initiatives are planned across the region. As a result, the next cycle of regional planning is ongoing, focused on regional needs in the Hamilton, Brant and Caledonia-Norfolk sub-regions. On average, an annual growth of three per cent, four per cent, and 5 per cent is expected for the Hamilton, Brant and Caledonia-Norfolk sub-regions, respectively. Industrial electrification projects, new development and intensification contribute to the increase in demand forecast. The Burlington to Nanticoke region is in close proximity, and shares key infrastructure with parts of the bulk power system. This will require coordination between the IRRPs and Central-West Bulk Plan to understand potential impacts of needs or solutions on the regional versus bulk system.

4 Demand Forecasts

This section describes the forecast demand for the Central-West area and the regions of interest. Ontario is becoming a leader in building electric vehicles and batteries, and the automotive sector is growing, with significant new developments from Stellantis in Windsor to Volkswagen in St. Thomas. In addition, Ontario's population is expected to grow by two million people by the end of this decade. As a result, Ontario's electricity demand is rising, especially in the Central-West area, encompassing southwestern Ontario.

The IESO's bulk planning looks at broad areas and growth factors, being responsive to customers and policy decisions. Thus, the growth scenarios considered in this Plan were driven by economic development, policy and governmental direction. The Central-West area is primed for economic development due to a number of factors. Large industrial loads are typically located where they have access not only to electricity, but also to a variety of other factors, all of which can be accessed within the Central-West area. This includes access to a skilled labour force, transportation to efficiently ship their product to serve multiple markets (e.g., Canada and the United States), lands that have been zoned appropriately, supply chain inputs and post-production processing, other utilities (e.g., water, wastewater, gas) and financial resources.

In order for the Plan to respond to these macroscopic factors, the demand forecast and scenario development had to evolve to reflect the unique characteristics of this new type of industrial development (i.e., large, lumpy loads in concentrated areas where the other services they require exist, with preference for low lead times for connection). As part of the process, the IESO engaged with, and received input from, the government on where growth is likely to materialize.

4.1 Growth Scenarios

The 2022 APO forecast was used as the basis to assess various load growth scenarios for the Central-West area, with two blocks of load layered on top – Firm Load in St Thomas and Potential Load in each of the five regions of interest – to create five growth scenarios.

The APO forecast incorporates many factors, including, but not limited to, the state of the economy, population, demographics, technology, energy prices, input fuel choices, equipment-purchasing decisions, consumer behaviour, government policy and conservation. The APO forecast exhibits strong and steady growth through the end of the 2030s, fuelled primarily by industrial sector development in the mid-2020s in mining, steel, EV battery and hydrogen production; agricultural sector greenhouse construction; and transportation sector electrification, before moderating in the early 2040s.

The APO Zonal forecasts for the relevant Zones in 2030 and 2043 are shown in **Table 1**, as it grows over the study period according to the APO forecast.

Table 1 | 2022 APO Zonal, Grid Forecasts (MW)

Station	Summer 2030	Winter 2030	Summer 2043	Winter 2043
West Zone	3,100	3,600	3,400	4,050
Southwest Zone	5,500	5,000	6,300	6,200
Niagara Zone	850	750	1,000	900
Bruce Zone	100	150	100	150

The APO forecast was then combined with two blocks of load: the Firm Load in St. Thomas, followed by the Potential Load in the five regions of interest, identified based on directional information received from the government, municipalities and public stakeholders. Details of the two blocks of load are as follows:

- **Firm Load:** this includes the Volkswagen EV plant in St Thomas, as well as additional ancillary and spin-off loads totalling 620 MW (690 MVA) within the London Area region, which is the assumed base forecast that must be met
- **Potential Load:** this includes 500-650[10] MW of economic development in each of the regions of interest, modelled separately in addition to the Firm Load

Thus, the five growth scenarios have the APO forecast as the basis, with a combination of the Firm Load and one Potential Load, as detailed in **Table 2**.

Table 2 | Growth Scenarios

Growth Scenario	Load Blocks Included
1	Firm Load + Potential Load in the London Area region
2	Firm Load + Potential Load in the Kitchener/Waterloo/ Cambridge/Guelph region
3	Firm Load + Potential Load in the Windsor-Essex region
4	Firm Load + Potential Load in the Chatham-Kent/Lambton/Sarnia region
5	Firm Load + Potential Load in the Burlington to Nanticoke region

Since the Potential Loads are speculative and not directly linked to a specific project, an annual demand forecast was not developed. Instead, a threshold-based approach was used for needs identification, as explained in Section 6.

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[10] 650 MW of Potential Load was considered in the London Area region, based on feedback received from the community of higher growth potential in this region and the relative impact it would have on the Firm Load. 500 MW of Potential Load was considered for all other areas.

5 Existing Supply to the Broader Central-West Area and London Area Region

This section describes the supply to the Central-West area and the London Area region specifically, (i.e., to supply the Firm Load), and it outlines the resource scenarios considered to determine the need for additional supply.

5.1 Existing Supply

The Central-West area is supplied by a number of internal wind and gas generation resources, as well as external resources accessed through the existing 230 kV network (connecting the area to the rest of Ontario).[11] The area also encompasses the entire Michigan interconnection, which allows for imports and exports to flow through Sarnia-Lambton and Windsor, and borders the Niagara region, which provides interconnection points with New York.

Specifically looking at the London Area region, it is supplied by four main sources: 1) resources in the West and Southwest Zones, primarily gas-fired generation in Sarnia-Lambton and Windsor-Essex, as well as wind and solar across the Zones; 2) resources in the Bruce Zone via Longwood TS, primarily nuclear and wind; 3) resources in the Niagara Zone, primarily hydroelectric and New York-Niagara interchange; and 4) resources from the rest of Ontario in the east via Middleport TS and Nanticoke TS.

As illustrated in **Figure 8**, there are four main interfaces of interest used to reflect these loads and resources:

- The **Buchanan-Longwood Input/Negative Buchanan-Longwood Input (BLIP/NBLIP) interface**, consisting of the circuits that connect the West Zone and the Southwest Zone, near the City of London, including three 500 kV circuits into Longwood TS and five 230 kV circuits into Buchanan TS. The NBLIP interface is identical to BLIP, but the power transfer is measured in the opposite direction (i.e., towards the east).
- The **Flow Away from Bruce Complex + Wind (FABCW) interface,** consisting of all the power flow from the Bruce Nuclear Generating Station, including the Bruce 230 kV and 500 kV stations (six circuits each), plus wind generation in the area.
- The **Queenston Flow West (QFW) interface,** consisting of the circuits that connect the Niagara Zone and the Southwest Zone. This includes the four 230 kV circuits out of Beck 2 TS and three 230 kV circuits into Middleport TS.

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[11] The mixture of resources used to supply the region's and the province's energy needs at any given time is determined by the real-time energy market.

- The **Flow East to Toronto (FETT) interface,** consisting of the circuits that connect the Southwest Zone and the Toronto and Essa Zones. This includes the four 500 kV circuits into Claireville TS, two 230 kV circuits out of Orangeville TS to Essa TS, and four 230 kV circuits out of Trafalgar TS to Richview TS and Hurontario SS.

Of these interfaces, the most significant source of supply to the Firm Load is through the NBLIP interface, transferring the significant amount of resources from the West Zone, which includes the Sarnia-Lambton area generation.

Figure 8 | Illustration of Key Bulk Interfaces for the Central-West Study*

*These interfaces and load indicators are representative of approximate locations.

5.2 Resource Scenarios

An objective of bulk studies is to identify concerns about the key bulk interfaces within the study area, which are illustrated in **Figure 8**. Preliminary screening indicated that the BLIP/NBLIP interface was the most impacted bulk interface when considering the connection of the Firm Load, specifically, high NBLIP flows, since the Firm Load straddles the BLIP/NBLIP interface. As a result, the immediate focus of the Central-West bulk study was to stress the BLIP/NBLIP bulk flows using the resources within the Southwest and West Zones, based on the following two resource scenarios:

- **Base Generation:** Expected BLIP flow achieved through existing and contracted resources at median contribution to peak, representing the expected contribution of resources to summer and winter peak hour, respectively
- **High Generation:** High NBLIP flow achieved through existing and contracted resources at Installed Capacity (ICAP) for non-renewable generation, and renewables at 10 per cent dependability, representing the maximum expected capability of available resources

Two sensitivities were performed for each case, considering additional imports and exports from Michigan to further stress the NBLIP flow. For the purposes of this study, the two resource scenarios were achieved using existing and planned resources in the West and Southwest to increase the BLIP/NBLIP flow and stress the interface. However, the use of these resources does not imply that they will remain after their contract term. Instead, it was a simplifying assumption to represent a future scenario where a significant amount of resources remain in the West Zone, irrespective of facility or resource type.

Resources in the Bruce and Niagara Zones were held constant, while resources from the rest of Ontario (Essa, Ottawa, East and Toronto Zones) were used as needed to balance any deficit or surplus of generation due to unequal transfers between the main sources above. **Table 3**, **Table 4** and **Table 5** summarize the key interface flows and resource assumptions for the four scenarios considered. Installed capacity is reflective of seasonal capacity and new resources secured through completed procurements.

Preliminary screening did not indicate any issues under high BLIP conditions (i.e., low generation in the West Zone and primary supply from the rest of Ontario into southwestern Ontario). However, further bulk studies will consider an additional low generation scenario, which will incorporate the Powering Ontario's Growth report actions, the new Clean Energy Regulations[12] and/or any relevant policy decisions.

Table 3 | Major Interface Starting Point Flows (MW)

Interface	Summer Base (MW)	Summer High (MW)	Winter Base (MW)	Winter High (MW)
FETL	200	2,300	-100	2,500
FABCW	4,900	5,000	4,900	5,000
QFW	1,900	1,900	1,900	1,900
FETT	1,300	4,000	1,600	5,400

Table 4 | Basecase Resources Assumptions (Summer, 2030)

Zone	Technology	Installed Capacity (MW)	Base Generation (MW)	High Generation (MW)
West Zone	Gas/Steam	3,800	2,000	3,600
	Solar	60	20	50
	Wind	1,500	210	650
	Storage and Other	90	50	90

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[12] Low generation assumptions to be developed during subsequent bulk studies. This Plan focused on base and high generation assumptions.

Zone	Technology	Installed Capacity (MW)	Base Generation (MW)	High Generation (MW)
	Total	5,500	2,250	4,400
Southwest Zone[13]	Gas/Steam	830	520	520
	Solar	190	70	170
	Wind	1,600	220	670
	Storage and Other	310	160	290
	Total	2,900	970	1,700
Bruce Zone	Total	7,300	5,200	5,200
Niagara Zone	Total	2,800	2,700	2,700

Table 5 | Basecase Resources Assumptions (Winter, 2030)

Zone	Technology	Installed Capacity (MW)	Base Generation (MW)	High Generation (MW)
West Zone	Gas/Steam	3,800	1,800	3,700
	Solar	100	0	0
	Wind	1,500	700	1,400
	Storage and Other	100	0	100
	Total	5,400	2,500	5,100
Southwest Zone[14]	Gas/Steam	800	500	500
	Solar	200	0	0
	Wind	1,600	300	1,300
	Storage and Other	600	300	500
	Total	3,100	1,100	2,400

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[13] Note, Halton Hills CGS is within the Southwest Zone, however, it is outside the Central-West area and so not included in this table.

[14] Note, Halton Hills CGS is within the Southwest Zone, however, it is outside the Central-West area.

Zone	Technology	Installed Capacity (MW)	Base Generation (MW)	High Generation (MW)
Bruce Zone	Total	7,300	5,300	5,300
Niagara Zone	Total	2,800	2,600	2,600

6 Needs Determination

This section describes the assessment of reliability for the Firm Load, and explores key constraints for the Potential Load in the five planning regions of interest. Given that this Plan is primarily focused on the bulk needs arising from the Firm Load in St. Thomas, the most restrictive scenario is Growth Scenario 1 (Firm Load plus Potential Load in the London Area region), coincident with summer peak demand and high generation or high NBLIP flow. The majority of the results in this section will reflect this scenario, with discussion of the preliminary findings for the other growth scenarios in Section 6.4.

6.1 Needs Identification Process

As described in Sections 4.1 and 5.2, for load growth and resource supply scenarios respectively, a number of key sensitivities were considered to determine the magnitude and timing of the need for additional supply capability, including considerations for rate of demand growth, varying levels of local resources, accounting for resources acquired through recent competitive acquisition processes, and interchange capability.

The assessment process was based on transfer analyses, starting with preparing the base case with the forecasted demand in 2030 from the APO, previously recommended transmission reinforcements and resource scenarios. Considering the season and resource scenarios, four cases have been prepared:

Case 1: Summer base generation

Case 2: Summer high generation

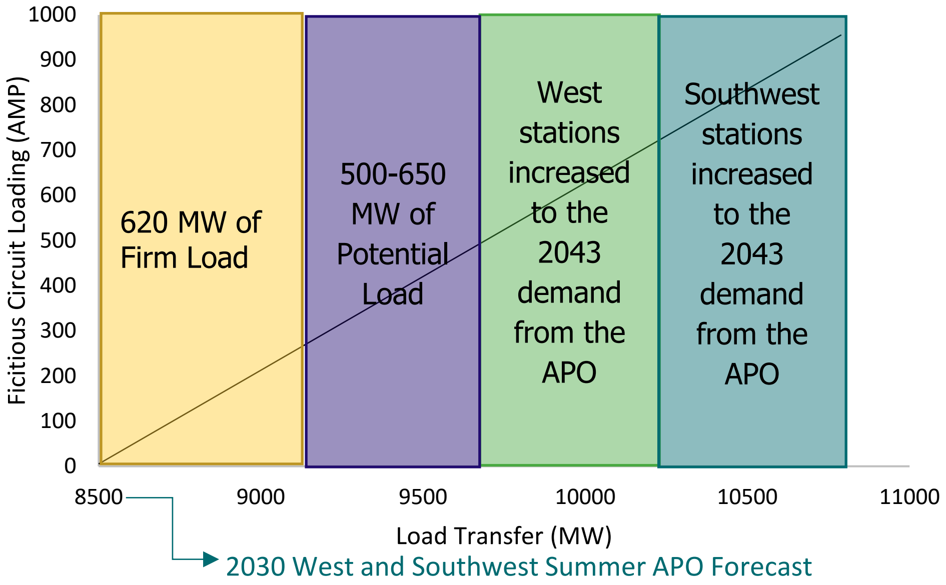
Case 3: Winter base generation

Case 4: Winter high generation

Resources in the West and Southwest Zones were varied based on the resource assumptions in Section 5. While load increases, as per the load transfers outlined in the following paragraph, available resources from the rest of Ontario (i.e., the Essa, Ottawa, East and Toronto Zones) are used to balance any deficit or surplus of generation.

For each of these four cases, five separate load transfers are conducted for each of the five planning regions of interest, as described in Section 3.2. The load transfer steadily increases the case from the starting point (the forecast demand in 2030 from the APO) to the Firm Load (620 MW), then increases one of the five Potential Loads in southwestern Ontario (500-650 MW), and finally increases the remaining stations to match the forecast demand in 2043 from the APO. Refer to **Figure 9** for an illustrative example of the load transfer.

Figure 9 | Illustrative Graph of Load Transfer



In order to assess reliability impacts, there are two key questions:

1) can the bulk supply lines accommodate the additional load?
2) what is the impact to the interface capability to deliver resources to the province?

Question one identifies a supply capacity need, while question two explores congestion and the potential impact on economic dispatch. To address violations to the transfer capabilities or system capabilities, wires and non-wires options are developed and evaluated to resolve the violations. To understand the impact to the interface deliverability, sensitivities were conducted with the addition of imports/exports from Michigan to further stress the NBLIP interface. This would identify any limitations transferring resources needed to supply load out of the West Zone, as well as any congestion. Congestion needs are not a transmission security violation, but rather identify potential economic benefit to all.

Typically for electricity planning, a specific year is identified as the need year, meaning that at that year, the existing transmission system is incapable of supplying the forecast demand and a solution is needed. Given the uncertainty of the Potential Load considered in this Plan, instead of identifying a need year, a load threshold approach was used. The capability of the existing system was identified and the need defined based on the amount of load that needs to materialize in a location. When customer commitments for the area reach the load threshold, the conditional plans identified in this Plan should be implemented.

Planning criteria were applied in accordance with NERC standards and the NPCC reliability directories to determine system capacity needs.[15] In the context of the bulk system, adequacy (i.e., system need) is defined as the ability to supply demand at all times, while respecting transfer capability limits across the bulk system and interconnections and taking into account scheduled and reasonably expected unscheduled outages of system elements.[16]

This assessment assumed that the recommendations of the 2021 West of London Bulk Report and 2019 Windsor-Essex bulk study were implemented (i.e., a transformer station in Lakeshore (Lakeshore TS) and a new double circuit 230 kV line between Lakeshore and Chatham (the Chatham west lines), a new double circuit 230 kV line between Lambton and Chatham, and a new single circuit 500 kV line between Longwood and Lakeshore (LxH) are in place). Thus, the 2030 transmission system and demand forecast were used as the basis of the analysis presented in this section.

The following sections outline the supply capacity, congestion, and other considerations identified resulting from this analysis. Note, not all cases resulted in identified needs, and only those that did are discussed.

6.2 Supply Capacity Need

Firm Load is directly connected to circuits comprising the NBLIP interface.

The NBLIP transfer capability is important for delivering supply from the West Zone to the Southwest Zone (in which the London Area region is located) and the rest of the province. This includes the output of generation and Ontario-Michigan imports in the Sarnia-Lambton area, as well as load in the Windsor-Essex region and Chatham-Kent area.

Study results found that the NBLIP transfers were thermally limited by circuits between Buchanan and Middleport, located east of where NBLIP is measured. The Firm Load directly connects to these circuits, which are on the NBLIP interface, and that connection is reducing the capability of those circuits to deliver planned and existing resources in the west. This is a security violation, and so a solution is needed.

Since it is recommended that the Firm Load should be connected to M31W+M33W,[17] which has a lower transfer capability than M32W+M33W, there is a supply capacity limitation identified after the majority of the Firm Load (600 MW) is connected. In addition, due to the sheer amount of load being added to the London Area region, voltage collapse concerns are also identified. The most limiting results for the summer Case 1 and Case 2 are stated in **Table 6**, which illustrate the main supply constraints.

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[15] Refer to Appendix A for details on the planning assessment criteria.

[16] Based on NERC's Reliability Terminology, https://www.nerc.com/AboutNERC/Documents/Terms%20AUG13.pdf.

[17] Refer to Appendix C for assessment of Firm Load connection configuration.

Table 6 | Supply Capability with Growth Scenario 1 (Firm Load + Potential Load in the London Area region), Summer

Case	Element(s) out of Service	Additional Supply Capability (MW)	Limitation	Limiting Contingency	Limiting Element
2	None	600	Thermal	M32W+M33W	M31W Buchanan TS to Firm Load tap
1,2	None	900	Low Voltage, Voltage collapse	M31W+M33W, M32W+Q25BM	Ingersoll TS

As a result, the following concerns were identified, to be addressed in this Plan:

- Unacceptable impact to the transfer capability of the NBLIP interface as 600 MW of major economic development is added in the London Area region, on top of forecast annual growth, resulting in thermal constraints on M31W between Buchanan TS and the project tap (i.e., where the Firm Load connects to the bulk transmission system)
- Voltage concerns as approximately 900 MW of major economic development is added, resulting in low voltage and voltage collapse at Ingersoll TS, due to the amount of load being supplied via one Middleport TS to Buchanan TS (MxW) circuit

The evaluation of options to address the M31W thermal limitation, or supply capacity need, is presented in Section 7, which will address the reliability concern.

To address the voltage collapse concern, dynamic, rather than static, voltage devices are required, to provide rapid response to system conditions and prevent cascading effects. Based on the assumptions of the Potential Load location, Ingersoll TS was identified as the best connection point for the voltage device. However, given that this is a long-term need, recommendations are conditional on load materializing, which will determine the optimal placement of such a device.

6.2.1 Pre-2030 Sensitivities

For Case 2 (Summer high generation), sensitivities were conducted considering the period 2028 to 2030, based on the reinforcements in-service:

1. **Post-2030:** with all recommended transmission reinforcements in-service, including the Longwood to Lakeshore 500 kV line (LxH), Lambton to Chatham (LxC), and Lakeshore to Chatham reinforcements in-service
2. **Pre-2030:** with only the Lambton to Chatham (LxC) and Lakeshore to Chatham reinforcements in-service
3. **Pre-2028:** with only the Lakeshore to Chatham reinforcement in-service

Figure 14 illustrates that prior to 2028, there will be approximately a seven and a half per cent to three per cent thermal overload on N21W without both the Longwood to Lakeshore 500 kV line and Lambton to Chatham 230 kV double circuit reinforcements for Case 2. The thermal overload occurs with the addition of approximately 450 MW of load, which is above the confirmed Volkswagen (VW) load. This risk needs to be managed for additional spin-off loads considered as part of the Firm Load. There are operational actions that can be utilized in the near-term, including the consideration of operational ratings, which are generally higher than planning ratings. The IESO will continue to monitor how spin-off loads and other loads materialize and the progress of the recommended transmission reinforcements, to assess the need for interim operational actions prior to 2030.

Figure 10 | Sensitivities to N21W Pre-contingency Loading without Reinforcements

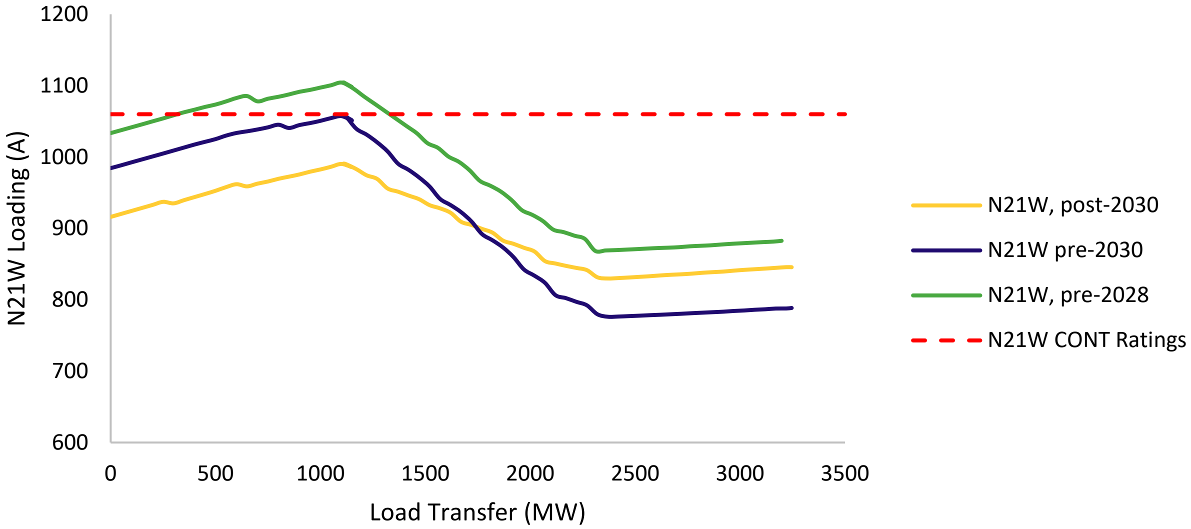
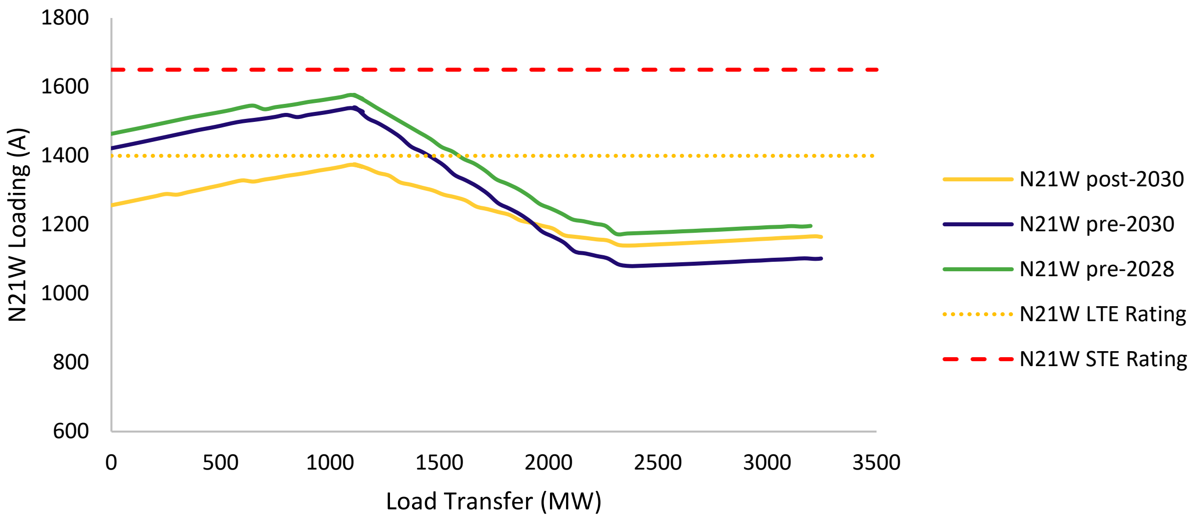


Figure 15 shows that considering the period 2028 to 2030, there are thermal violations prior to the LxH being in-service, with respect to the LTE rating. However, these are eliminated when applying the STE rating, as allowed per ORTAC.

Figure 11 | Sensitivities to N21W Post-Contingency Loading without Reinforcements



6.3 Congestion Need

In addition to meeting established criteria and standards, the IESO also seeks to enable economic efficiency, such as reducing losses and congestion, and facilitating intertie/trade requirements. Supply capacity and congestion needs are differentiated as described below.

A supply capacity need exists when projected flows across a bulk interface exceed the transfer capability under the assumed growth and resource scenarios considered. This results in insufficient supply to meet projected demand, as identified for the NBLIP interface in the previous section. Supply capacity needs, also referred to as "security" needs, are typically based on a snapshot of peak demand conditions. In a situation where generation capacity shortfalls are projected for the province and/or Zone as a whole, a security need may also emerge if firm sources of capacity are bottled and non-deliverable to load centres. Note that firm sources of capacity in this context refers to contracted generation/storage, intermittent resources discounted to reflect their expected contribution in peak demand conditions, and firm imports.

On the other hand, congestion is the condition under which the energy trades that market participants (such as generators and importer/exporters) wish to implement exceed the capability of the IESO-controlled grid.[18] Congestion needs are typically based on hourly energy simulations to forecast flows across interfaces based on demand, resource availability, economic resource dispatch, and intertie energy transactions.

There are several control actions that the operator can take to reduce congestion, such as changing reactive dispatch, arming RASs, and manually constraining generation and electricity storage up or down. Thus, per Ontario Resource and Transmission Assessment Criteria (ORTAC) Section 4.1, which provides information on transfer capability degradation criteria, new or modified connections to the IESO-controlled grid may increase congestion on transmission facilities, but are not permitted to lower power transfer capability or operating security limits by five per cent or more.

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[18] As defined in ORTAC, Section 4.6.

This section details the analysis that was conducted using imports to further stress the interface flows to identify any congestion concerns. First, it is established that the Firm Load does not reduce the transfer capability of critical interfaces by more than five per cent. Beyond the supply capacity need, the next limitation is seen on the Nanticoke TS to Buchanan TS (NxW) circuits. However, with respect to the application of the five per cent transfer capability degradation criteria, the NBLIP interface is not the appropriate bulk transmission interface, rather the Flow East Towards London (FETL) interface is more appropriate. Analysis of the FETL interface found that Growth Scenario 1 is not expected to result in more than four per cent degradation of the bulk interface.

Second, it is shown that while the Firm Load and Potential Load do increase congestion, the impact is minor. Analysis of the impact of imports to further stress the flow east found that while Growth Scenario 1 increases congestion, this is not expected to occur more than two per cent to four per cent of the time, based on projected flows for the APO Case 2 Ontario-only and multi-area models respectively. This represents an incremental increase of one and a half per cent to three per cent relative to without the Growth Scenario. This is not expected to be a concern for provincial energy needs, due to the marginal impact relative to the significant amount of load considered and since non-firm imports are required to reach the higher end of this range, based on the best available information of resources in the West Zone at this time. Instead, this translates to a lower ability to trade over system peak demand.

6.3.1 Transfer Capability Degradation

It was determined that the NBLIP interface is not the appropriate bulk transmission interface to assess transfer capability degradation due to the load increase in London. FETL measures the ability to transfer or export power from the West of London area to the London Area region, where a strong transmission hub exists to transmit this power to the rest of the Ontario grid (Longwood TS), and is, hence, the more appropriate transmission interface to apply the transfer capability degradation criteria of no more than five per cent. Refer to **Table 7** for the definitions of NBLIP and FETL. FETL was similarly used to determine the need for the Lambton to Longwood Transmission Upgrade Project in 2012, in order to enhance deliverability of system resources.

Table 7 | Interface Definitions

Interface	Inteface Name	Definition
NBLIP	Negative Buchanan-Longwood Input	N582L, B562L, B563L, M31W, M32W, M33W, D4W, D5W measured at Buchanan TS and Longwood TS
FETL	Flow East Towards London	N21W, N22W, L24L, L26L, W44LC, W45LS, new Longwood to Lakeshore 500 kV circuit

Under the high generation scenario with the import sensitivity, with an FETL flow of 2,700 MW and all previously recommended reinforcements in-service, without the Firm Load, up to 500 MW of imports can be achieved before reaching a pre-contingency thermal limitation on the NxW circuits. As shown in **Table 8**, with the Firm Load, under the same generation conditions, and an FETL flow of 2,600 MW, up to 330 MW of imports can be achieved, resulting in a degradation of four per cent.

Table 8 | Impact of the Firm Load on Key Interfaces

Interface	Flow without Firm Load (MW)	Flow with Firm Load (MW)	Degradation (%)
FETL	2,700	2,600	-4
Michigan Imports	500	330	n/a

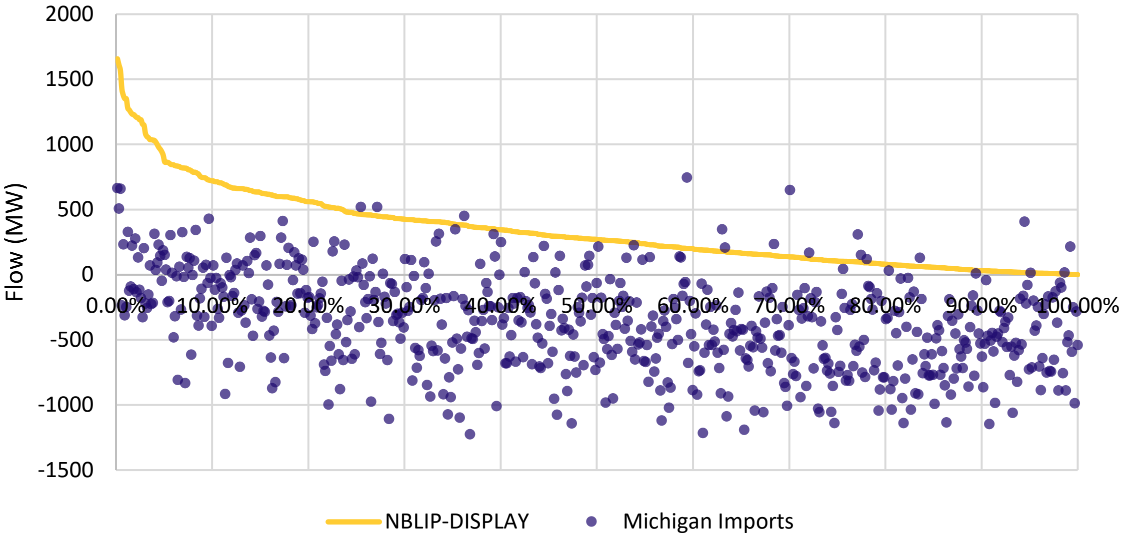
6.3.2 Congestion Assessment

While the true congestion phenomena is on the FETL interface, the results of this section still reference NBLIP flows, since IESO’s energy simulations are set up to monitor NBLIP. NBLIP and FETL flows are highly correlated – both interfaces measure bulk flow from the West Zone eastwards, but differ in the specific circuits and points at which the measurement is taken. The FETL congestion limitation correlates to an NBLIP flow of 1,300 MW with the Firm Load. In other words, achieving an NBLIP flow greater than 1,300 MW would require full dispatch of West Zone resources coincident with 330 MW of imports and peak load.

Based on historical and projected flows on the NBLIP interface, there is limited need to maintain NBLIP flows above 1,300 MW. These results are based on the APO Case 1, which assumes that resources are not maintained once their contract expires. There is sufficient bulk transfer capability across the NBLIP interface to deliver existing and planned resources west of London. Instead, this limitation indicates that it is not possible to transfer the full capability of western generation and full Michigan imports at the same time as Ontario demand is peaking. Thus, the need to maintain full NBLIP capability would be more dependent on how much new generation is sited in the West Zone and is therefore a congestion need, not a security need.

Over the last five years, NBLIP flows have exceeded 1,300 MW approximately one per cent of the time.

Figure 12 | Historical NBLIP Duration Curve with Michigan Imports, 2018-2022



Based on the 2024 APO energy models,[19] considering the Ontario-only model, NBLIP flows are only projected to exceed 1,300 MW two per cent of the time (between 2023 and 2050). NBLIP flows greater than 1,300 MW are seen in the Ontario-only energy models when demand in the West Zone is lower than the peak values assumed in the congestion studies. Considering the multi-area model with interchange, NBLIP is projected to exceed 1,300 MW four per cent of the time (see **Figure 13**). Without the Firm Load, flows are expected to exceed the NBLIP flow of 1,600 MW, which correlates to the FETL flow without the Firm Load, approximately a half per cent to one per cent of the time. This results in a one and a half per cent to three per cent increase in congestion due to the addition of Firm Load.

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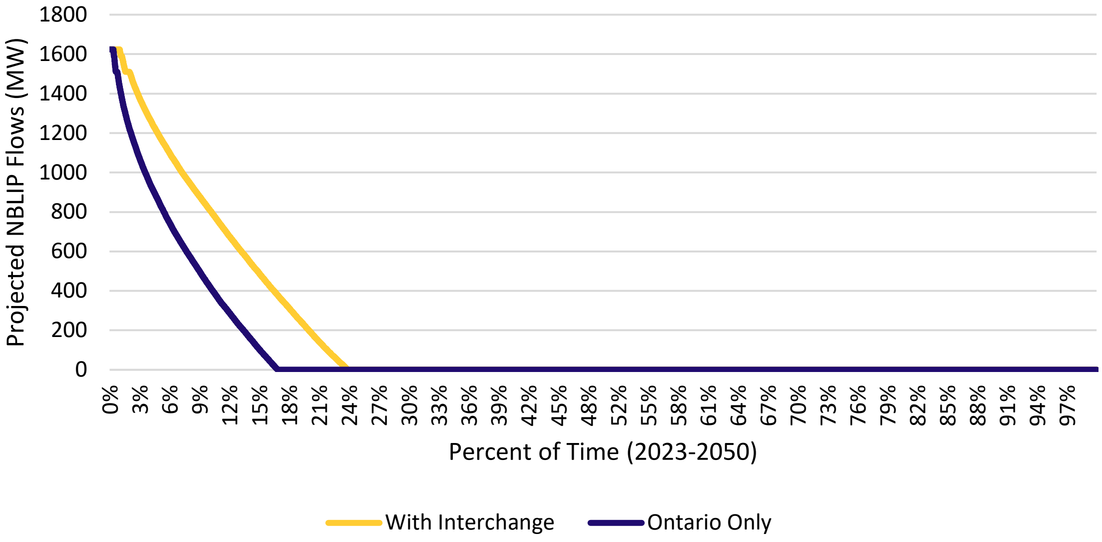
[19] APO Case 2 forecast, which assumes that resources continue to be available post-contract/post-commitment expiry for the duration of the study period, consistent with the resource scenario assumption, to represent the worst case scenario.

Figure 13 | Projected NBLIP Duration Curve



6.4 Future Considerations

The impact of the Firm Load plus Potential Load in the London Area region was found to be compounding (i.e., Potential Load in the London Area region has the greatest impact to the phenomena limiting supply to the Firm Load). As such, this Plan focused on Growth Scenario 1 (Firm Load + Potential Load in the London Area region). This section describes the findings for the other growth scenarios considering the 2022 APO forecast in 2030, as well as further bulk or regional studies that may be required to assess the potential needs and options.

On July 10, 2023, the Ministry of Energy released the POG report, which outlines actions to support economic growth, decarbonization, and the ongoing transformation of Ontario's electricity system. The Ontario government is planning the electricity infrastructure for a more electrified Ontario, where economic growth continues to drive new jobs and emissions continue to be reduced. The South and Central Ontario bulk planning study being initiated this year will consider the impact of the objectives of the POG report across southwestern Ontario. The Central-West report identifies linkages and potential reliability concerns, which will be integrated with POG objectives to better plan for potential linkages and their cumulative impact, as detailed in the following sections.

6.4.1 Growth Scenario 2

Preliminary studies considering Growth Scenario 2 (Firm Load + Potential Load in the Kitchener-Waterloo/Cambridge/Guelph region) indicate that thermal limitations are seen on the transmission paths between Detweiler TS and Orangeville TS, as well as the 115 kV path between Burlington TS and Detweiler TS. This is seen both pre-contingency and under outages to a Middleport TS to Detweiler TS circuit, a Detweiler TS to Orangeville TS circuit, or two Bruce to Longwood TS circuit outages. However, these limitations are independent of the Firm Load or Potential Load in the London Area region. Thus, no firm recommendations are made at this stage. This should be monitored and inform the South and Central Ontario bulk planning study and the next cycle of regional planning.

Low voltage and eventual voltage collapse at Preston TS was identified after approximately 1,110 MW of load is added under Growth Scenario 2. Additional reactive support may be needed at Buchanan TS or closer to Preston TS. With an outage to a Detweiler TS to Orangeville TS or a Middleport TS to Detweiler TS circuit, this concern is triggered earlier. However, this is a local limitation, not directly linked to the Firm Load, and so should inform the next cycle of regional planning.

6.4.2 Growth Scenario 3

Preliminary studies considering Growth Scenario 3 (Firm Load + Potential Load in the Windsor-Essex region) indicate a correlation between Potential Load in this region and Potential Load in the London Area region. With higher load in the west, under Growth Scenario 1, there is less flow east on the FETL or NBLIP interface. Thus, there is a balance between the addition of load or resources in this region with load or resources in the London Area region, with respect to maintaining the bulk transfer capabilities. Subsequent bulk and regional plans will monitor the impact of load growth in this region on the NBLIP congestion identified.

Hydro One is currently undertaking early development work on a second 500 kV line between Longwood TS and Lakeshore TS. This Plan reaffirms that the need for this line is conditional on additional load materializing in the Windsor-Essex region. Subsequent bulk and regional plans will monitor the impact of load growth in this region on the need for this reinforcement, as loads materialize.

In addition, considering Potential Load in the Windsor-Essex region in combination with the West of London forecast for agricultural growth in the region, there is a need for additional voltage support. This need is seen especially during the winter, when the Potential Load coincides with peak agricultural load. This voltage concern should inform the ongoing Windsor-Essex IRRP, when considering high regional demand.

6.4.3 Growth Scenario 4

Preliminary studies considering Growth Scenario 4 (Firm Load + Potential Load in the Chatham-Kent/Lambton/Sarnia region) indicate the same correlation to Potential Load increases in the west of London area, as seen in the Windsor-Essex region. Higher load in the west of London area results in less congestion on the FETL or NBLIP interface, as resources supply the Windsor-Essex and Chatham-Kent/Lambton/Sarnia regions within the West Zone, thus reducing the flow out of the Zone towards the London Area region. Thus, there is a balance between the addition of load or resources in these two regions with load or resources in the London Area region, with respect to maintaining the bulk transfer capabilities. Subsequent bulk and regional plans will monitor the impact of load growth in this region on the NBLIP congestion identified.

While this Plan considered economic development in each of the five regions of interest, growth in Sarnia-Lambton is more accurately considered in terms of net load. There is an existing generation source and further changes to the resource mix resulting from the POG report or the proposed federal Clean Electricity Regulations would net out some or all load increases in this pocket. As a result, considering the net impact of generation and load will increase the range of scenarios to be considered in subsequent South and Central Ontario bulk studies to support the POG report.

6.4.4 Growth Scenario 5

Considering Growth Scenario 5 (Firm Load + Potential Load in the Burlington to Nanticoke region), no bulk concerns are anticipated with additional Potential Load, since there is robust supply in this region. However, changes in the supply mix in southwestern Ontario, as contemplated in the POG report, will impact the characteristics of the area, which will inform subsequent South and Central Ontario bulk studies to support the POG report.

7 Options Evaluation and Recommendations

Section 5 indicated that there was an unacceptable impact to the transfer capability of the NBLIP interface. This resulted in:

1. Thermal constraints on the M31W supply circuit to the tap point of the Firm Load
2. Voltage concerns needed to maintain the capability of bulk system interfaces, while supplying the Firm Load and additional load in the London Area region

This section details the assessment of options to address this need and recommends the most effective solution to maintaining supply for future loads in the area.

7.1 Options Analysis

To determine the most cost-effective way to relieve the unacceptable impact to the transfer capability of the NBLIP interface, the following options were considered to address the thermal limitation identified:

- **Option 1: Reinforce the existing transmission supply circuit.** This option considers the reinforcement of the supply circuit, M31W, between Buchanan TS and the Firm Load tap point. The 2-5 km transmission line would maintain the capability of the bulk system while increasing the supply transfer capability by 300 MW.[20]
- **Option 2: Local resources.** In this option, the identified capacity and energy needs are met through the addition of the least-cost, non-emitting resource alternative, located between the Firm Load tap point and the Firm Load. This analysis included additional resources capable of increasing the supply capability by 300 MW, with two sensitives for how load may grow:
  - Sensitivity A: Resources are staged in with an assumed gradual ramp up over five years to meet incremental load requirements
  - Sensitivity B: The full amount of resources are in-service from the start of the need, paralleling the transmission reinforcement supply

Both options increase the supply capability by 300 MW, which addresses the last 20 MW of the Firm Load and a significant portion of the next pocket of Potential Load considered in the London Area region.

In Option 1, the transmission reinforcement has the potential to provide additional transfer capability, but is constrained by voltage limitations.

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[20] The transmission option can provide a total of approximately 450 MW of transfer capability based on thermal constraints, however, it is limited to 300 MW by voltage concerns. Voltage support is required to achieve the full transfer capability improvement.

Option 2 was evaluated considering cost benchmarks based on non-emitting resource types capable of supplying the magnitude of energy and capacity required – new wind in combination with a new battery energy storage system (BESS).[21]

Other wires and resource options, including a new switching station, wind, solar, biomass and a small nuclear reactor were considered as potential cost benchmarks for the analysis, but were screened out or determined to be incapable of meeting the need due to technical limitations or long lead times. Other non-wires options, such as energy efficiency, distributed generation, and demand response were also considered, but were screened out as unsuitable due to the magnitude, location and uncertainty of the growth. Conservation and demand management options are more likely to be feasible if the need is roughly less than two per cent of the total demand forecast for each year. For this Plan, an annual forecast was not developed due to the uncertainty of the load growth, but 300 MW is roughly 30 per cent of the total load added (620 MW of Firm Load and 300 MW of Potential Load), indicating that this option is not feasible. In contrast, the feasibility of distributed generation options is limited by the available connection space at each transformer station. Distribution generation resources would need to be connected to the tap connection, which would not have the connection capacity space to accommodate 300 MW of distributed generation. Similarly, demand response is limited to the loads connected to the tap point, which are assumed to be very large industrial loads that are generally not demand-responsive, but require constant supply to maintain their industrial processes. However, the planned energy efficiency and use of existing distributed energy resources were incorporated into the demand forecasts.

7.1.1 Cost Considerations

Comparing the required transmission reinforcement to the resource alternative, the transmission reinforcement results in a net present value (NPV) cost saving of approximately $4 billion to $17 billion. The impact of a gradual ramp rate (Sensitivity A vs B) was negligible, compared to the impact of resource costs and capacity benefit, which drove the range in cost savings seen in **Table 9**.[22]

For Option 1, the capital cost of transmission was assumed to be $9 million to $40 million, based on a range of circuit costs. The NPV accounts for the system energy costs required to supply the 300 MW of additional load that is otherwise supplied by the new resource in Option 2.

Table 9 | Net Present Value Comparison of Option 1 and 2 ($B)

Option	Description of Option	Cost ($B)
1	M31W reinforcement between Buchanan TS and Firm Load tap	3
2	Combination of Wind and BESS Resources	7-20

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[21] The ultimate resource type may be subject to subsequent competitive procurements, as required.

[22] Refer to Appendix B for details on the resource cost and capacity benefit assumptions.

The hourly energy profiles for both the Firm Load and Potential Load were assumed to follow a typical industrial load profile, which is relatively constant in terms of business days through the year, with roughly 15 per cent variability between peak and off-peak periods. Due to the sustained periods of energy need, approximately 2,800 MW of wind resources and 300 MW (1,800 MWh) of BESS was needed for the Option 2 resource alternative, making it prohibitively expensive.

These results indicate that transmission reinforcement is the most cost-effective option.

7.1.2 Resource Considerations

Aside from providing energy, acquired supply resources under Option 2 could provide additional benefits to the system through reliability services (e.g., operating reserve) and system capacity value to supply provincial needs.

Historically, a gas-fired turbine has been the pricing benchmark for new resources in Ontario. However, the potential for local opposition to new gas generation facilities and proposed regulations restricting emissions from electricity generators render gas-fired turbines higher risk. Therefore, a gas-fired turbine was not considered for this assessment.

For a resource to meet the need described in Section 5, it must be located at the Firm Load tap point, or between the tap and the Firm Load supply station. Ideally, the generation would be directly connected to an integrated transmission station, which means either it connects at the Firm Load supply station or a new station is built. It must also be capable of providing a significant energy component, along with the required capacity, since industrial loads are assumed to have a generally constant energy need throughout the day.

Approximately 2,800 MW of wind, in combination with 1,800 MWh of storage, would be required to meet the need. This amount of wind is roughly half of Ontario’s existing installed wind capacity. In addition, a significant amount of land would be needed to site all required wind in close proximity to the tap point – approximately 850 hectares. Such a large volume of resources creates untenable supply chain, project cost, and timeline risks. In addition, as this is a location-specific need, it would be unlikely to be met through provincial procurements.

7.1.3 Transmission Considerations

The transmission option would require rebuilding the towers between Buchanan TS and the tap to accommodate higher capacity conductors. M31W was previously reinforced to accommodate the largest single conductor size used by the transmitter (Hydro One). As such, the M31W towers are smaller than M32/33W, and are limited by clearances and span lengths. Thus, increasing the conductors on M31W with the existing towers would not increase the transfer capability, to maintain the required clearances for farmland and farm equipment. To reinforce M31W, the transmission line would need to be rebuilt with new towers.

The option of building a switching station at the Firm Load tap point was considered to sectionalize and connect the three MxW circuits. While this would balance the flows across the three supply circuits and provide some voltage support, thermal constraints on M31W are still the limiting phenomena, and so this does not address the supply need. In addition, the high-level cost for this option is $175 million to $200 million, at least five times greater than the transmission reinforcement option.

The current Buchanan TS is space limited in terms of adding additional circuits beyond one element, as well as regarding egressing the station, due to the station configuration and location adjacent to Highway 401. Since there is space at Buchanan TS to terminate one more circuit, the option to construct a new 230 kV circuit from Buchanan TS to the tap was considered. However, in order to connect the new circuit to the Firm Load, a switching station would be needed, making this option cost prohibitive.

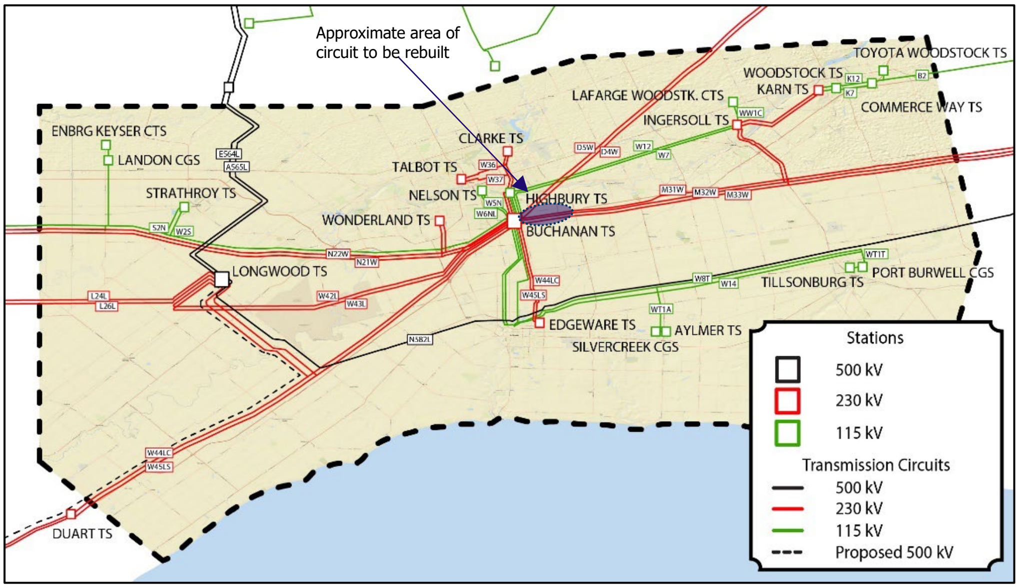
While rebuilding the towers between Buchanan TS and the tap provides additional transfer capability, further reinforcements will eventually be necessary to support future load growth. Depending on where further load materializes and how the transmission system evolves, extending the scope of the rebuild of M31W or adding an additional circuit between Buchanan TS and Middleport TS could be required. Since the preferred option is to reinforce the transmission line and rebuild the towers, an assessment was conducted to consider whether double circuit towers (i.e., towers that can carry two circuits) should be used to accommodate future potential circuits along this path. The planning estimate for double circuit towers is roughly the same as that of single circuit towers, given the margin of error of high-level costs. This would leverage the one remaining termination available at Buchanan TS and allow for the tower construction, without needing to first remove M31W from service. Importantly, this would preserve the option to quickly add a second circuit if/when it is required. The second circuit would further increase the transfer capability across the London Area region, while maintaining load security. Thus, it would be prudent to reconstruct the section between Buchanan TS and the Firm Load tap with double circuit towers, considering the marginal cost difference and potential long-term benefits.

7.2 Recommendations

Based on the analysis presented in this section, the IESO recommends rebuilding the supply circuit, M31W, between Buchanan TS and the Firm Load tap point with double circuit towers strung with one circuit (see **Figure 16**). This preserves the option for a future additional 230 kV circuit to continue to supply the area, depending on where and when further load growth materializes. It is recommended that this work begin immediately, assuming a five-year lead time for implementation.

Dynamic voltage devices are also needed across the area as load grows and, in particular, at Ingersoll TS if more than 300 MW of Potential Load materializes in the London Area region.

Figure 14 | Approximate Location of Circuit to be Rebuilt



Approximate area of circuit to be rebuilt

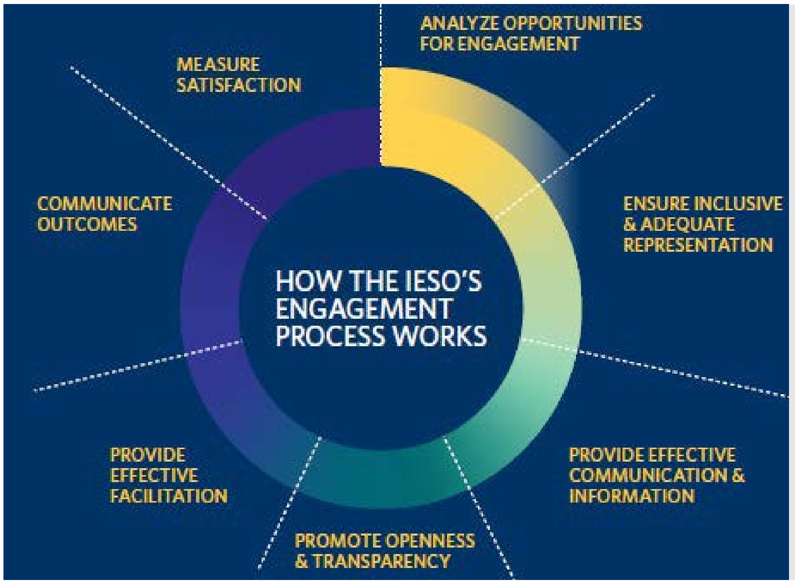
8 Community and Stakeholder Engagement

Engagement is critical in the development of an electricity plan. Providing opportunities for input in the regional planning process enables the views and perspectives of the public, which for these purposes, refers to market participants, stakeholders, communities, First Nations and Métis peoples, customers, and the general public, to be considered in the development of the Plan, and helps lay the foundation that helps inform its decision-making. This section outlines the engagement principles and activities undertaken for the Central-West Bulk Plan.

8.1 Engagement Principles

The IESO's engagement principles (see **Figure 17**) help to ensure that all interested parties are kept informed. They also enable opportunities for purposeful engagement to contribute to electricity planning initiatives, such as the development of this Plan. The IESO adheres to these principles to ensure inclusiveness, sincerity, respect and fairness in its engagements, striving to build trusting relationships as a result.

Figure 15 | The IESO's Engagement Principles



8.2 Engagement Approach

To ensure that the Plan reflects the needs of market participants, stakeholders, communities, First Nations and Métis peoples, customers, and the general public, engagement involved:

- Leveraging the Southwest Bulk Planning Initiatives webpage and Central-West Bulk Planning engagement webpage on the IESO website to post updated information, engagement opportunities, meeting materials, input received and IESO responses to the feedback
- Communication with communities, stakeholders and interested parties through email, Southwest Regional Electricity Network updates, and the IESO weekly Bulletin

- Public webinars
- Targeted outreach throughout plan development with municipalities, customers, and those with an identified interest in southwest Ontario electricity issues

Two public webinars were held at major junctures during plan development to give interested parties an opportunity to hear about its progress and provide comments on key components including:

- Electricity demand growth scenarios
- Identified needs
- Options evaluation
- Recommendations

Both webinars received strong participation with stakeholders in attendance, and resulted in the submission of written feedback during the two-week comment periods.

Engagement was instrumental in garnering feedback about expected economic development across southwestern Ontario being driven by high industrial growth, as well as increased growth in residential and commercial developments. Comments received during this engagement focused on the following major themes:

- Alignment and coordination with other municipal and community planning, local developments, growth plans and the impact of decarbonization is needed. Future infrastructure and/or electricity supply should consider the priorities of energy and climate action plans and, in particular, alternative energy systems, renewable generation, electrification and climate resilience.
- Consideration should be given to non-wires alternatives, such as distributed energy resources and demand side solutions, as part of the recommended solutions.
- Concern around potential delays in needed electricity infrastructure to enable investments and economic development should be considered.
- Integrated options that provide both local and broader provincial system benefit should be considered.
- Shifting economies, in particular for different resource technologies, should be incorporated into planning assumptions and cost benefit analysis.
- Integration with other IESO regional and bulk planning activities, Annual Planning Outlooks, energy procurements, and governmental policy and directives should be carried out.

Based on the discussions about both the Central-West Bulk Plan and parallel Windsor-Essex regional planning initiative, it is clear that there is broad interest in several southwestern Ontario communities to further discuss the potential for solutions that fully utilize existing transmission infrastructure and minimize the footprint of solutions.

The feedback received helped to guide further discussion throughout the development of this Plan and add due consideration to the final recommendations.

All background information, including the engagement plan, engagement meeting presentations, recorded webinars, detailed feedback submissions, and responses to comments received, are available on the IESO's Central-West bulk planning engagement webpage.

8.3 Bringing Communities to the Table

The IESO informed municipalities and key stakeholders of the development of this Plan and recommendations. The IESO was available to discuss and address any key issues of concern and options for meeting those future needs.

8.4 Engaging with Indigenous Communities

To raise awareness about the bulk transmission planning activities underway in Ontario for 2024 and provide an overview of the Central-West Bulk Plan, outreach was offered to all Indigenous communities in Ontario. They were invited to attend a targeted meeting in April 2024 to provide an opportunity shape how engagements are approached for bulk transmission studies going forward. Those invited to participate, who are within southwestern Ontario, include the communities of Saugeen Ojibway First Nation, Nawash First Nation, Chippewas of the Thames First Nation, Mississaugas of the New Credit, Six Nations of the Grand River, Haundenosaunee Confederacy Chiefs Council (HCCC), Haundenosaunee Development Institute (HDI), Aamjiwnaang First Nation, Bkejwanong (Walpole Island First Nation), Métis Nation of Ontario, Chippewas of Kettle and Stony Point, Caldwell First Nation, Oneida Nation of the Thames, Munsee Delaware and Moravian of the Thames.

The IESO remains committed to ongoing and meaningful engagement with Indigenous communities, to help shape long-term planning in regions all across Ontario.

8.4.1 Indigenous Participation and Engagement in Transmission Development

The IESO determines the most reliable and cost-effective option and publishes those recommendations in the applicable regional or bulk planning report. Where the IESO determines that the lead time required to implement recommended solutions requires immediate action, the IESO may provide those recommendations ahead of the publication of a planning report, for example, through a handoff letter to the lead local transmitter in the region.

As part of the overall transmission development process, a proponent applies for applicable regulatory approvals, including an Environmental Assessment that is overseen by the Ministry of Environment, Conservation and Parks (MECP). This process includes, where applicable, consultation regarding Indigenous and treaty rights, and approvals may include measures to avoid or mitigate impacts on said rights. MECP may delegate the procedural aspects of consultation to the proponent while maintaining oversite into those delegated aspects and the consultation process generally. Following development work, the proponent will then need to apply to the OEB for approval through a Leave to Construct hearing, and only if approval is granted, can it proceed with the project.

In consultation with MECP, project proponents are encouraged to engage with Indigenous communities and rights-holders on ways to enable participation in these projects.

9 Conclusions and Recommendations

This document describes the Plan that has been developed for the Central-West bulk study, and recommends measures to ensure continued, reliable supply to the Firm Load in the London Area region. This Plan has been coordinated with regional plans, including the ongoing Windsor-Essex and Burlington to Nanticoke IRRPs.

The bulk study recommends immediately reconstructing the M31W circuit between Buchanan TS and the Firm Load tap point (approximately 2-5 km in length), assuming a five-year lead time. This will relieve the unacceptable impact to the transfer capability of the NBLIP interface and allow the connection of approximately 300 MW of Potential Load in London Area region beyond the Firm Load. Furthermore, it is recommended that the new M31W towers be rebuilt as double circuit towers, strung with one circuit but capable of accommodating a second circuit in the future, if/when needed. This would preserve the option to quickly increase the transfer capability across the London Area region even further, if the Potential Load location or amount shifts from the assumptions in this Plan. Since this recommendation is to reconstruct the existing transmission infrastructure, it is expected that the incumbent transmitter would be in the best position to proceed with this work.

Dynamic voltage devices are also needed across the area as load grows, and in particular at Ingersoll TS if more than 300 MW of Potential Load materializes in the London Area region.

For the recommended transmission solutions, the next steps would include the transmitter proceeding with development work, including applicable regulatory approvals, before proceeding with implementation and construction.

The IESO, along with the relevant distributors and transmitters, will continue to monitor the load growth, progress of developments toward plan deliverables, conservation measures, and pace of new connections in the London Area region and southwestern Ontario as a whole, to identify any impacts on completed or future bulk and regional plans and recommendations for the regions of interest.

On July 10, 2023, the Ministry of Energy released the Powering Ontario's Growth report, which outlines actions to support economic growth, decarbonization, and the ongoing transformation of Ontario's electricity system. As per that report, the Ontario government is planning for a more electrified Ontario, where economic growth continues to drive new jobs and emissions continue to be reduced. The South and Central Ontario bulk planning study being initiated this year will consider the objectives of the POG report across southwestern Ontario, as detailed in the IESO's 2024 Annual Planning Outlook.

Consideration of Potential Loads for the other planning regions of interest identified in the Central-West Plan will be integrated with POG objectives in the South and Central Ontario bulk planning study to better plan for potential linkages and their cumulative impact. Regional concerns identified in the Central-West Plan for Windsor-Essex and Kitchener-Waterloo/Cambridge/Guelph regions will inform ongoing or upcoming regional planning activities.

Appendix A: Application of Criteria

In developing this bulk plan, the IESO followed a number of steps including:

- Data gathering, including development of electricity demand forecasts
- Conducting technical studies to determine electricity needs and the timing of these needs
- Developing potential options
- Preparing a recommended plan including actions for the near and longer term

Throughout this process, engagement was carried out with stakeholders interested in the area, in the form of public webinars and targeted discussions with the affected communities, local distribution companies and transmitters.

This Plan documents the inputs, findings and recommendations developed through the process described above and provides recommended actions for the various entities responsible for plan implementation. The Plan helps ensure that recommendations to address near-term needs are implemented, while maintaining the flexibility to accommodate changing long-term conditions.

The overall objectives of planning are consistent among both regional and bulk planning, which are the following:

- Ensure reliability and service quality
- Enable economic efficiency
- Support sector policy and decision making

There are various reliability standards that, as the electricity system planner and operator, the IESO is obliged to meet. NERC and NPCC membership requires that the bulk system be planned to consider specific operating conditions, such as peak and light load, and a set of contingencies to ensure the bulk system is planned reliably and meets standards. Additionally, the IESO is required to demonstrate its adherence to these standards through compliance reporting.

Reliability standards require the IESO to define its own performance criteria that must be met under the conditions and contingencies specified. The Ontario Resource and Transmission Assessment Criteria (ORTAC) define the planning performance criteria for Ontario, which are more specific and/or more stringent standards than NERC/NPCC. The IESO also considers operational issues and solutions that simultaneously consider bulk system reliability needs, regional needs, and assets reaching end of life, as appropriate.

The study used the planning criteria in accordance with events and performance as detailed by: NERC TPL-001 "Transmission System Planning Performance Requirements" (TPL-001), NPCC Regional Reliability Reference Directory #1 "Design and Operation of the Bulk Power System" (Directory #1), and IESO ORTAC.

In addition to meeting established criteria and standards, the IESO also seeks to enable economic efficiency and support sector policy. Bulk system planning has a role in ensuring policy objectives can be incorporated with maximum benefit to ratepayers, and in identifying opportunities for improving overall system economics, especially in a competitive environment. This includes seeking economic opportunities, such as reducing losses, congestion, or other service costs, facilitating intertie/trade requirements, and providing timely and relevant information to market participants to enhance their participation and decision-making leading to greater market efficiency and competition. It also includes supporting policy implementation affecting the power grid, such as sensitivity analysis of the economic impact of carbon pricing policies on congestion costs, as well as considering community energy plans and goals.

Thermal Criteria

Table 10 shows the thermal criteria used for the Central-West studies. Post-contingency loadings up to the STE ratings is allowed only if the operator confirms they can manually resolve the thermal violations within 15 minutes. For a breaker-failure contingency, the operator can generally isolate the failed breaker and restore the unfaulty elements within an acceptable time and reduce the impact to single-element, post-contingency loadings up to the STE ratings are considered acceptable.

Note that the STE rating of a line should be recalculated for outage conditions if the pre-contingency loading of the line is larger than its continuous rating. The STE ratings that are normally provided were calculated for pre-contingency flows equal to the continuous ratings.

Table 10 | Thermal Criteria – Applicable Ratings

Condition	Pre-Contingency	Single-element Contingency	Common-tower Contingency	Breaker-failure Contingency
All In-service	Continuous	LTE	STE	STE
Outage	LTE	STE*	STE*	STE*

* STE rating must be recalculated for any element whose pre-contingency flow is larger than the continuous rating. The STE ratings that are normally provided were calculated for pre-contingency flows equal to the continuous ratings.

Voltage Criteria

Table 11 shows the voltage criteria based on ORTAC. Note that only main stations at 115 kV and higher voltage levels are monitored and tapped junctions and buses in the middle of circuits are not.

Table 11 | Voltage Criteria - ORTAC

Criterion	Nominal Voltage 500 kV	Nominal Voltage 230 kV	Nominal Voltage 115 kV
Maximum pre/post-contingency voltage	550 kV	250 kV	127 kV
Limited-time maximum post-contingency voltage*	575 kV	263 kV	133 kV

Criterion	Nominal Voltage 500 kV	Nominal Voltage 230 kV	Nominal Voltage 115 kV
Minimum pre-contingency voltage	490 kV	220 kV	113 kV
Minimum post-contingency voltage	470 kV	207 kV	108 kV
Maximum post-contingency absolute voltage deviation	10%	10%	10%

* Applicable only if voltages can be brought below their steady state post-contingency maximum limits within 30 minutes.

Arming RASs

With any one element out of service, arming an existing Remedial Action Scheme (RAS) is allowed only to account for local generation outages. Not more than a total 150 MW of load can be interrupted by configuration and load rejection.

With any two elements out of service, arming an existing Remedial Action Scheme (RAS) beyond 150 MW is allowed only to account for local generation outages. is allowed only to account for local generation outages. Not more than a total 600 MW of load can be interrupted by configuration and load rejection.

Note that locally-controlled voltage-based schemes such as Under Voltage Load Shedding (UVLS) and reactor/capacitor switching schemes are not RASs and can be used without restriction.

Respected Contingencies

Transfer capabilities, if reached, were derived based on single-element and common-tower contingencies. Breaker-failure contingencies were not be included in the initial transfer studies, but were evaluated with the transmission reinforcement option and resource scenarios in order to identify further needs. The rationale for not including breaker-failure contingencies in the initial transfer analysis is as follows:

- A breaker-failure contingency in a station usually removes two circuits on two different paths from that station. This should not be more limiting than the common-tower contingencies which removes two circuits on the same path.
- An operator can normally isolate the failed breaker and restore the unfaulty elements within an acceptable timeframe and reduce the contingency to a single-element.
- The contingency assessment used for the selected outages should identify voltage collapse scenarios encompass or exceed those resulting from a breaker-failure contingency.

Also, based on the study and based on the engineering judgment, contingencies in regions not relevant to the interfaces under study may be excluded.

Appendix B: Economic Assessment Assumptions

The following is a list of the assumptions made in the economic analysis:

- The net present value (NPV) of the cash flows is expressed in 2023 CAD.
- The USD/CAD exchange rate was assumed to be 0.77 for the study period.
- The NPV analysis was conducted using a four per cent real social discount rate.
- A long-term annual inflation rate of two per cent is assumed. A near-term (2023-2024) annual inflation rate of four per cent was assumed.
- The assessment was performed from an electricity consumer perspective and included all costs incurred by project developers, which were assumed to be passed on to consumers.
- The NPV study period for the options analysis term extended from the start of 2029, the year that the solution would need to be in-service, to the end of 2098, when a transmission asset replacement decision would be required.
- The life of the transmission line was assumed to be 70 years; and the life of the generation and storage assets was assumed to be 20 years. Cost of asset replacement were included where necessary to ensure the same NPV study period.
- Development timelines for transmission was assumed to be 3-6 years; development timelines for generation and storage were assumed to be 3-5 years following a procurement.
- Capital costs for the transmission options were determined based on $4.5 million to $8 million per kilometre estimates for a new double circuit 230 kV line, and a $175 million to $200 million per station estimate for new switching station costs. This was informed by the West of London Bulk Report analysis, Lakeshore switching station cost estimates in the Leave to Construct application evidence on file with the Ontario Energy Board, and input received from Hydro One.
- Both options will require voltage control devices, preferably in the form of small capacitors and reactors and/or automatic regulation in the form of a static var compensator sited with the new loads. Since this was common to all options, these costs were not factored into this analysis. The details of the voltage requirements will be specified in subsequent System Impact Assessments (SIA) for each project.
- Sensitivities to test the impacts of the how quickly Potential Load in the London Area materializes on the NPV were performed. Once the need in each sensitivity surpassed the capability of the transmission solutions being evaluated, the demand was flat lined for the purposes of the production cost analysis. While NPVs were calculated based on the life of the longest asset (70 years), holding the need at 300 MW (the incremental capability achieved through the transmission reinforcement) ensures an equal comparison of options.

- The combination of wind and storage resources was identified as one of the lowest-cost, non-emitting resource alternatives that could potentially be built in time to meet the need identified. The estimated levelized cost of capital and fixed operating costs assumed is about $150,000-160,000/MW (2023 CAD) for wind and $210,000-270,000/MW (2023 CAD) for storage for sensitivity A, and $350,000-380,000/MW (2023 CAD) for wind and $210,000-270,000/MW (2023 CAD) for storage for sensitivity B. Costs are based on the 2023 National Renewable Energy Laboratory (NREL) Annual Technology Baseline (ATB) Workbook publication, and accounts for the impact of the Clean Investment Tax Credit. Total energy storage system costs are composed of capacity and energy costs (i.e. energy storage devices are constrained by their energy reservoir), for a six-hour storage resource. Cost ranges were developed by using different wind production profiles.
- Sizing of the storage solution was based on meeting the peak capacity and peak energy requirements for the local reliability need, such that the reservoir size is capable of using existing gas resources to sufficiently charge to meet the hours of unserved energy.
- Sizing of the storage option for the purposes of this analysis was conducted assuming perfect foresight, i.e. demand is predictable and so the facility knows exactly when and how much energy is needed and charges ahead of time, sometimes requiring multiple days to charge, in order to supply that need.
- Resources were assumed to be sited at the preferred location, at the Firm Load tap point or between the tap and Firm Load supply station, up to the capability of the existing system.
- The magnitude of demand growth in this area exceeds the capability of energy efficiency or demand response to cost-effectively reduce the needs, and were therefore not considered as alternatives, but is considered further through ongoing regional planning in the area.
- System capacity value was $159,000/MW-year (2023 CAD) based on an estimate for the cost of a portfolio of non-emitting resources. A low sensitivity was assessed with a system capacity value of $37,000/MW-year (2023 CAD), reflecting the winter 2024/2025 Capacity Auction Clearing Price.
- The cost of constraining the generation alternative to produce energy for a local need versus the cost of system supply was considered.
- A resource’s potential contribution to system needs, outside of serving the local needs, was assessed based on the deliverability of that resource’s remaining capacity to province’s load centre.

Appendix C: Connection Configuration Requirement

Based on the location of the Firm Load, up to 180 MW can be connected to Buchanan TS via the existing 230 kV tap lines between Buchanan TS and Edgeware TS, consistent with Hydro One's proposed connection to the customer. The remaining 440 MW of Firm Load must be connected to the electricity system from the Buchanan to Middleport 230 kV circuits, consistent with Hydro One's proposed connection arrangement to the customer. To maintain redundant supply, the Firm Load must have dual supply (i.e., be supplied via two of the three Buchanan to Middleport 230 kV circuits: M31W, M32W and M33W). However, there are differences in transfer capability and load security between the three 230 kV circuits along the Buchanan to Middleport path.

M32W supplies both Ingersoll TS and Brantford TS, while M31W only supplies Ingersoll TS and M33W supplies Brantford TS (the smaller of the two stations). Thus, the option to connect the Firm Load to M31W and M32W was not considered because the circuits are already heavier loaded.

Two connection options were considered: M31W+M33W, and M32W+M33W.

Based on the results shown in this section, the recommended connection for the Firm Load is M31W+M33W.

M31W+M33W Connection Assessment

Studies indicate that there are post-contingency thermal constraints for the M31W+M33W connection after 600 MW of Firm Load is added, under high generation assumptions. There are also low voltage concerns in the London Area region after 900 MW of load is added (620 MW of Firm Load and 380 MW of Potential Load in the London Area). There are no load security constraints identified.

Thermal and Voltage Assessment

The thermal rating for M31W is lower than the other two circuits, as shown in **Table 12**.

Table 12 | Current Summer Thermal Ratings for the MxW Circuits (Buchanan TS to Salford JCT)

Circuit	Continuous Rating (93˚C) A	Continuous Rating (93˚C) MVA	LTE Rating (127˚C) A	LTE Rating (127˚C) MVA
M31W	1,100	440	1,500	580
M32W	1,400	550	1,800	730
M33W	1,400	550	1,800	730

Under the base generation assumptions, there are no pre- or post-contingency thermal concerns identified to supply the Firm Load – 620 MW of load transfer can be achieved before reaching a thermal limitation. However, beyond 800 MW (620 MW of Firm Load + 180 MW of additional load in the London Area region), post-contingency thermal constraints are seen following the loss of M32W+M33W. An upgrade to the M31W circuit would be needed to enable further load in the London Area, with the base generation.

Under the high generation assumptions and no imports, post-contingency thermal limitations on M31W are seen when the Firm Load is 600 MW, for the loss of M32W+M33W.

The next constraint for both the summer base and high generation cases is seen when approximately 900 MW of load is added, when the load flow case does not solve for contingencies that result in the loss of MxW circuits. This occurs immediately after the low voltage concerns, and indicates that there are voltage collapse concerns at Ingersoll TS due to the sheer amount of load being added.

Similar but less restrictive results are seen for the winter cases, due to the higher winter thermal ratings.

The results of the thermal and voltage assessment are summarized in **Table 13**.

Table 13 | Supply Capability with M31W+M33W Firm Load Connection

Generation Scenario	Element(s) out of Service	Additional Supply Capability (MW)	Limitation	Limiting Contingency	Limiting Element
Base	None	800	Thermal	M32W+M33W	M31W Buchanan TS to Firm Load tap
High	None	600	Thermal	M32W+M33W	M31W Buchanan TS to Firm Load tap
Base/High	None	900	Low Voltage	M31W+M33W, M32W+Q25BM	Ingersoll TS
Base/High	None	900	Voltage Collapse	M32W, M31W M32W+M33W, M31W+Q23BM, M32W+Q25BM	Ingersoll TS
Base/High	M32W	900	Low Voltage	Pre-contingency	Ingersoll TS

Load Security Assessment

Considering load security criteria, an N-1-1 (loss of M31W and M33W) would result in the Firm Load connected to the MxWs being lost (430 MW; 620 MW less the 190 MW load connected to the tap to Buchanan TS), which is within the 600 MW limit for load security in ORTAC.

No voltage violations were identified.

M32W +M33W Connection Assessment

Studies indicate that there are post-contingency thermal constraints on M32W for the loss of M33W with M31W out of service, after approximately 940 MW of load (620 MW of Firm Load and 320 MW of Potential Load). There are also low voltage concerns in the London Area region after approximately 900 MW of load is added (620 MW of Firm Load and 380 MW of Potential Load in the London Area region). Load security constraints are identified beyond 620 MW of Firm Load.

Thermal and Voltage Assessment

Under the base generation assumptions, there are no pre- or post-contingency thermal concerns identified to supply the Firm Load – 620 MW of load transfer can be achieved before reaching a thermal limitation. However, beyond ~940 MW (620 MW of Firm Load and 320 MW of Potential Load), post-contingency thermal constraints are seen following the loss of M33W with M31W out of service. Since this occurs under outage conditions, a RAS is permissible under ORTAC criteria, so no upgrades are required.

Under the high generation assumptions and no imports, there are no thermal concerns identified to supply the Firm Load – 620 MW of load transfer can be achieved before reaching a thermal limitation. However, beyond ~750 MW (620 MW of Firm Load and 130 MW of Potential Load), post-contingency thermal constraints are seen for the N-1-1 (i.e., following the loss of M33W with M31W out of service). Since this occurs under outage conditions, a RAS is permissible under ORTAC criteria, so no upgrades are required.

The next constraint for both the summer base and high generation cases is seen when approximately 980 MW of load is added, resulting in the load flow case not solving for the loss of M32W+M33W, M31W+Q23BM, and M32W+Q25BM. This indicates that there are voltage collapse concerns at Ingersoll TS due to the sheer amount of load being added.

Similar, but less restrictive, results are seen for the winter cases, due to the higher winter thermal ratings.

The results of the thermal and voltage assessment are summarized in **Table 14**.

Table 14 | Supply Capability with M32W+M33W Firm Load Connection, Summer

Generation Scenario	Element(s) out of Service	Additional Supply Capability (MW)	Limitation	Limiting Contingency	Limiting Element
Base	M31W	940	Thermal	M33W	M32W Buchanan TS to Firm Load tap
High	M31W	750	Thermal	M33W	M32W Buchanan TS to Firm Load tap
Base/High	None	980	Voltage Collapse	M31W*	Ingersoll

*Also seen for other configurations that remove one MxW circuits.

Load Security Assessment

Considering load security criteria, an N-2 or N-1-1 (loss of M32W and M33W) would result in the Firm Load connected to the MxWs being lost (430 MW; 620 MW less the 190 MW load connected to the tap to Buchanan TS) plus the load at Brantford TS (140-170 MW between 2030 and 2043), which would violate the 600 MW limit for load security in ORTAC.

Comparison of Connection Options

The amount of additional load (Firm Load and/or Potential Load) that can be supplied in the London Area region is outlined in **Table 15** for both connection options, based on the most restrictive case (summer high generation). The M31W circuit has the lowest transfer capability of the three, primarily due to the smaller clearances and span lengths required to accommodate the surrounding farmlands and farm equipment. Thus, from a thermal perspective, more load can be enabled through the M32W+M33W connection.

Table 15 | Additional Supply Capability for the Firm Load Connection Options

System State	All In-Service Additional Supply Capability (MW)	All In-Service Limitation	Outage Supply Capability (MW)	Outage Limitation
Current System, load connected to M31W and M33W	600	Thermal	600*	Thermal
Current System, with load connected to M32W and M33W **	980	Voltage	750*	Thermal

* Assumed to be equal to all in-service limit, as the end state for the n-1-1 is the same as the n-2 condition.

** Based on the 2030 forecast, M32W+M33W contingency without any Firm Load removes Brantford TS.

However, the M32W+M33W connection configuration violates the load security criteria, for which operational measures are not available. Hence, it is recommended that the Firm Load connect to M31W+M33W.