Need for Bulk Transmission Reinforcement in the Windsor-Essex Region

June 13, 2019

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1 Executive Summary

This report documents the results of a planning study the IESO initiated to assess the adequacy of the bulk transmission system in the Windsor-Essex Region and recommends preferred near- and mid-term solutions to address identified needs. This analysis was triggered by recent unprecedented growth in forecast electricity usage for the greenhouse sector in the Kingsville-Leamington area. The anticipated level of growth is significant - the region's electrical demand is expected to double over the next five years. While this report focuses on near- and mid-term bulk electricity needs and solutions, it also touches on the potential mid- to long-term system needs if load continues to grow in the region and further work involved in order to trigger any additional long-term reinforcements, when required.

While the scope of this study is related to the bulk system supplying the Windsor-Essex Region, a separate regional planning study is underway. This companion study focuses on developing an integrated regional resource plan ("IRRP") to provide customers in the region with adequate line connection and step-down transformation capacity, and maintain a level of reliability consistent with accepted planning standards. Information from the IRRP, such as demand forecasts and plans for new connection facilities inform this bulk planning study. Recommended solutions in both studies have been integrated as they impact bulk and regional needs.

Based on the results of the two studies, the IESO recommends the following new bulk system facilities to address the near- and mid-term system needs:

- A new switching station at or near the existing Leamington Junction, as shown in Figure 1, to improve the capability to supply additional transformer stations ("TS") and large transmission customers that are planning to connect to that part of the Windsor-Essex power grid;[1] and,
- A new 230 kV double circuit transmission line from the existing Chatham Switching Station ("SS") to the new switching station at the Leamington Junction, as shown in Figure 1.

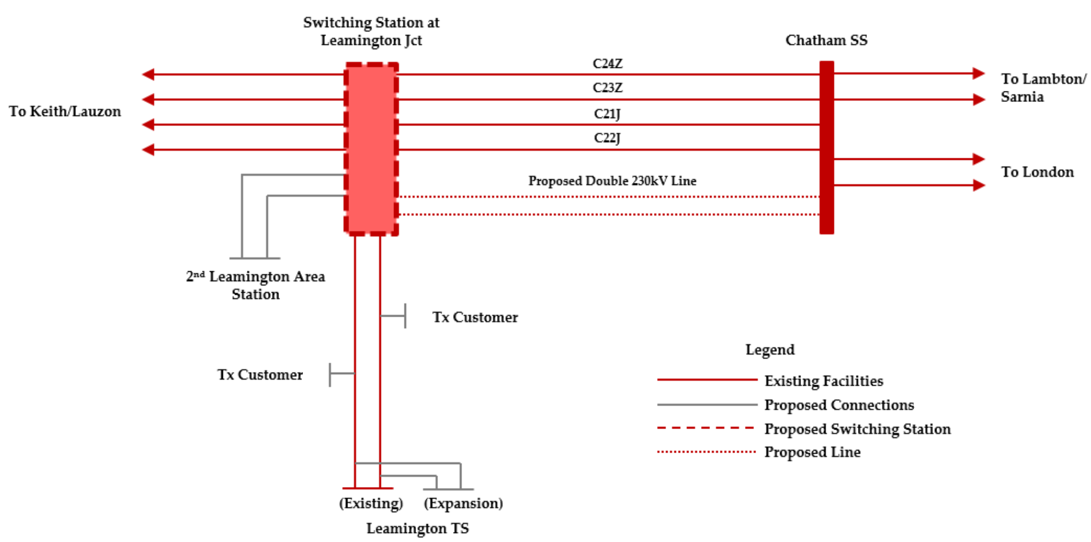
[1] Note, the need for this transmission reinforcement was triggered earlier within this bulk planning process, and work to develop the project is currently proceeding. For more information on the IESO hand-off letter, including frequently asked questions, read the backgrounder: http://www.ieso.ca/-/media/Files/IESO/Document-Library/regional-planning/Windsor-Essex/FAQs-Leamington-SS-Hand-Off-Letter-Final.pdf

This line will:

a) increase 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 the broader Windsor-Essex Region in the near- to mid-term,
b) permit the resources and bulk facilities in this region to operate efficiently for local and system needs, and
c) maintain existing interchange capability on the Ontario-Michigan interconnection between Windsor and Detroit.

Based on current assessments, the IESO recommends an in-service date of 2022 for the switching station and prior to the winter of 2025/2026 for the transmission line.

Figure 1: Single Line Diagram of Existing and Proposed Facilities in the Leamington Area



This report outlines the assumptions and results of the bulk system assessments which evaluated both the needs and alternatives for the area. The transmission alternative was compared to least-cost resource alternative, using typical costs for a simple cycle natural gas turbine.[2] For the current planning assumptions and the evaluated load growth scenarios, new transmission was found to be the most cost effective and technically feasible option to meet identified system needs in a timely manner. For the needs considered, the transmission option

[2] Other resources and non-wires alternatives were considered but based on the profile of capacity and energy required, a simple cycle natural gas turbine was determined to be the least-cost resource alternative capable of supplying the need.

has a net present value ("NPV") approximately $500M lower than the least cost resource alternative for the most likely scenario.

The IESO will work with identified transmitters to implement the recommended solutions. In parallel, the IESO, working with local distribution companies ("LDCs") in the area, will continue to monitor project progress and connection of load in the region. Additional bulk transmission facilities may be required in the mid to long term. Additionally, the Windsor-Essex IRRP study may identify other connection needs in the region.

2 Introduction

In April 2015, the IESO published an IRRP for the Windsor-Essex Region, which recommended the Supply to Essex County Transmission Reinforcement ("SECTR") project. The scope of this project included an extension - approximately 13 km - of two existing 230 kV circuits from Chatham SS to Keith TS (located in Windsor), south to Leamington to supply a new transformer station for the area, Leamington TS #1.

Prior to this recommendation, load in both the Leamington and Kingsville areas, had been supplied from the existing Kingsville TS, which was fully utilized and unable to accommodate additional load growth.

In early 2018, the SECTR project came into service, providing an additional 200 MW of winter local load meeting capability to the Kingsville-Leamington area. Between the 2015 IRRP recommendation and the completion of the project in 2018, LDCs in the area, particularly Hydro One Distribution, received a large number of customer connection requests. These requests exceeded both the capability of the new station and the total load forecast for the area in the 2015 IRRP. This increase in forecast growth for the region triggered the second cycle of regional planning for Windsor-Essex, which is currently underway.[3]

To respond to customers' need for electrical connection in the area, Hydro One Distribution and Hydro One Transmission ("Hydro One") decided to proceed with an expansion of the recently constructed Leamington TS #1 (Leamington TS #2, with a targeted in-service date of early 2020), to double the amount of capacity that can be supplied from the station to 400 MW. Concurrently, the IESO and Hydro One also received a number of requests – totalling about 100 MW – from larger customers wanting to connect to the new Leamington transmission line. Together, these new connections cannot be accommodated on the existing transmission system while meeting required planning criteria. Interim measures have been identified to allow the connection of some new facilities to continue and will be included as part of the recommendations of the System Impact Assessments ("SIAs") for these projects.

System reinforcements are required to alleviate the need for these interim measures and to strengthen the bulk transmission supply to the region to enable further load connections. This report identifies the region's needs and presents a comparison of the alternatives considered to meet near- to mid-term supply requirements.

[3] The IRRP for the Windsor-Essex area is due to be published in September 2019. More information on regional planning for Windsor-Essex can be found on the IESO engagement page: http://www.ieso.ca/Get-Involved/Regional-Planning/Southwest-Ontario/Windsor-Essex

This report is organized into the following sections:

- Section 3 provides background on the Windsor-Essex Region, Kingsville-Leamington area, and the broader West of London area;
- Section 4 discusses planning considerations for the Windsor-Essex Region and context for the Leamington supply solutions;
- Section 5 describes the Windsor-Essex Region's electricity conservation and demand;
- Section 6 describes the Windsor-Essex Region's internal and external supply resources, as well as the need for additional supply;
- Section 7 analyzes the transmission and resource alternatives considered to meet the identified needs; and
- Section 8 provides the IESO's recommendation and outlines the major milestones in the implementation of Leamington supply solutions.

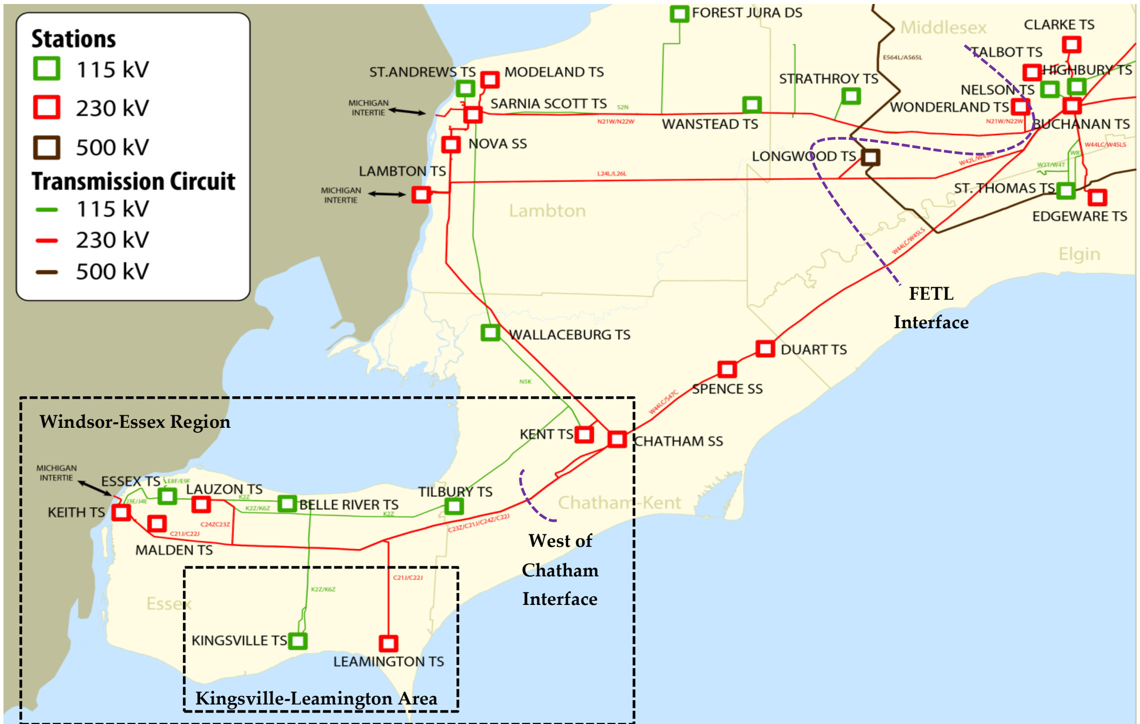
3 The Windsor-Essex Region

As the southernmost portion of Ontario, the Windsor-Essex Region extends southwest from Chatham to Windsor. Although the region is home to approximately 400,000 people, its electricity demand is defined by its economic activity. The region's history of automotive manufacturing, particularly near the city of Windsor, is accompanied by entertainment tourism in the city's core and large food processing operations throughout Essex County.

While the manufacturing sector in the Windsor-Essex Region continues on a downward trend in line with the recent automotive industry, economic diversification has triggered other changes to the region's electricity demand. The Kingsville-Leamington area within the Windsor-Essex Region includes North America's largest concentration of greenhouse vegetable production. With agricultural businesses in this local area expanding rapidly, interest in cannabis growth operations developing, and the adoption of artificial crop lighting becoming commonplace, electricity supply requirements to the Kingsville-Leamington area will continue increasing significantly. Due to the substantial growth in the area, any local supply needs have to be assessed along with the bulk system supply.

The Windsor-Essex region is part of the West of London bulk transmission system, which contains of a number of significant wind and gas generation resources. The generation resources in the West of London area are relied on for servicing load in western Ontario, including Windsor-Essex. Resources west of London also act as an important supply to the Greater Toronto Area, via the Flow East Towards London ("FETL") Interface. In addition, Ontario's existing transmission interconnection with Michigan is located within the West of London area, with connections in Sarnia, Lambton and Windsor. Figure 2 shows the broader West of London area in relation to the Windsor-Essex Region and the Kingsville-Leamington area.

Figure 2: Map of West of London Area, and Windsor-Essex Region



Supply to the Windsor-Essex Region from generation resources located in the eastern portion of the West of London bulk area is through the West of Chatham interface (the four 230 kV circuits from Chatham SS supplying the region). A number of generation resources are located within the Windsor-Essex region itself, contributing significantly to local supply.

Due to the significant amount of growth forecast for the Windsor-Essex region, and the concentrated nature of the load growth within the Kingsville-Leamington area, additional supply reinforcement is required at both the regional and bulk system level.

Before the system needs for the broader Windsor-Essex area can be assessed, the local need for system reinforcement, driven by initial customer connections in Kingsville-Leamington over the near term, has to be addressed. The transmission reinforcement required to meet this local need for load supply is discussed in section 4. The remainder of the report compares new transmission to strengthen the connection within the West of London area to the Windsor-Essex Region, and new local generation within Windsor-Essex to address the broader upstream system needs assuming this local reinforcement is in place.

4 Leamington Load Supply

To adequately supply the additional load that will begin connecting in the Kingsville-Leamington area in 2020 (with the expansion to Leamington TS #1), system reinforcements are required for step-down transformation, connection capacity and local reliability. The need and scope of facilities for this local reliability issue were explored primarily through the IESO's regional planning process.

To accommodate the expansion of Leamington TS #1 and the connection of additional transmission customers starting in early 2020, interim measures are required resulting in a lower level of reliability to connecting customers than what is typically provided. Beyond these connections and interim measures, the existing system does not have the ability to accommodate the total amount of forecasted load for the Kingsville-Leamington area, discussed further in section 5.2.

The limitation on the existing supply to the Kingsville-Leamington area is caused by voltage decline at Leamington TS #1 and #2 under both single and double contingencies (loss of one or more 230 kV transmission circuits). To respect this limitation, the line to Leamington TS #1 and #2 can only accommodate 370 MW of load based on the Ontario Resource and Transmission Assessment Criteria ("ORTAC").[4] With interim measures, which allow for the rejection of load when a transmission circuit is lost, the amount of load that can be supplied in the Leamington area can be temporarily increased to approximately 500 MW. However, this results in lower reliability for new customers until reinforcements can be put in place.[5]

The IESO has requested that Hydro One establish a switching station at the Leamington Junction by 2022 to improve the local load meeting capability of the Kingsville-Leamington area. The proposed switching station will improve reliability, and provide some additional local supply capability to connect an additional transformer station and continue supplying load in the Kingsville-Leamington area. The switching station will increase the local load meeting capability to approximately 700 MW by 2022.[6] The on-going regional planning process will continue to explore options for future load connections, which could necessitate additional transmission connection assets or local upgrades.

Various alternatives to the switching station were considered in the regional planning process including non-wires options and other wires solutions. Due to the magnitude and the timing of

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[4] See *Ontario Resource and Transmission Assessment Criteria*, issue 5.0, available here: http://www.ieso.ca/-/media/files/ieso/Document%20Library/Market-Rules-and-Manuals-Library/market-manuals/market-administration/IMO-REQ-0041-TransmissionAssessmentCriteria.pdf

[5] The SIA for these connections will outline the requirements that must be met by the connection applicants, including actions required as a result of identified violations of the ORTAC.

[6] Determination of local load meeting capability makes assumptions around the dispatch of local generation (typical dispatch levels at system peak), bulk system flow limitations, and flows on the interchange between Ontario and Michigan (assumed to be zero for the determination of local/regional supply capability).

the need, non-wires alternatives alone are not sufficient. A generation option located at Leamington Junction was considered, but was deemed impractical due to its technical infeasibility and the anticipated cost. The build of a new radial 230 kV circuit from Chatham SS to Leamington TS was also ruled out on the basis that the load meeting capability would be insufficient to meet forecasted load growth or provide the flexibility to supply future growth beyond the Leamington TS #2 expansion.

In addition to improving load supply capability in the Kingsville-Leamington area, the proposed switching station will improve the performance of the bulk system by balancing the flow on the existing transmission circuits from Chatham, this improves the transfer capability of the West of Chatham interface which supplies the broader Windsor-Essex Region. The switching station will also reduce exposure to outages by allowing the existing 230 kV circuits to be sectionalized and switched independently.

5 Windsor-Essex Demand

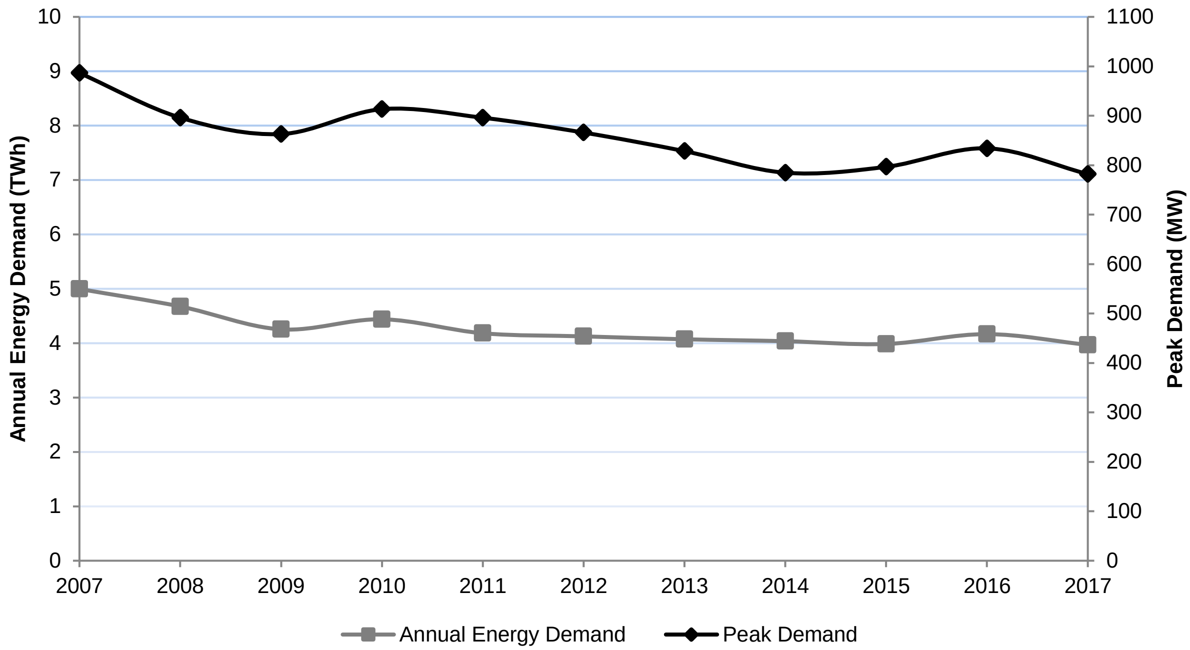
This section describes historical and forecast demand for the Windsor-Essex Region overall, and in detail for the local Kingsville-Leamington area, as it is the primary driver of demand growth for the region.

5.1 Historical Demand

Historically, the electric system in the Windsor-Essex Region has been summer-peaking, with the primary load centre being the city of Windsor.

Between 2013 and 2017, the annual energy requirements and coincident peak demand in the Windsor-Essex Region were around 4 TWh and 800 MW, respectively. Prior to 2008, summer peak demand was considerably higher, at approximately 1,000 MW. After 2008, summer peak demand decreased to around 900 MW, and continued to trend downward with the transition from heavy manufacturing to less energy intensive industry. Historical demand and energy consumption for the region are shown in Figure 3.

Figure 3: Historical Summer Demand and Energy Consumption for the Windsor-Essex Region



Arising from its historically higher load levels, the Windsor-Essex Region currently has a number of Remedial Action Schemes in place. While these protection schemes were implemented to improve reliability to the Windsor-Essex area when load levels, particularly automotive loads, within the city of Windsor were higher, they are still used today (e.g., under high import or export conditions). However, it should be noted that the Windsor-Essex Region was not able to sustain its past peaks without these protection schemes, which include generation and load rejection.

Load in the Kingsville-Leamington area has also historically exceeded the capability of existing transmission infrastructure (i.e., Kingsville TS - the main supply point to the area prior to the completion of the SECTR project). Historical load at Kingsville TS has ranged from 120-130 MW of summer peaking load. In the past (as well as today), the region's protection schemes have been used to accommodate this demand, by interrupting load in the Kingsville area following recognized contingencies in the region. While this facilitated higher load than the Kingsville TS capability, local customers experience reduced reliability compared to the rest of the Ontario system.

In recent years, forecast demand in the Kingsville-Leamington area has increased significantly, as seen in Figure 4. This is primarily driven by expansion of the greenhouse sector (vegetable and, in part, cannabis, production). Until the recent SECTR transmission expansion in the area, load growth had been constrained by the capability of Kingsville TS. Load growth in the area will increase the frequency of use of the protection schemes mentioned above and require new protection measures for customers that are currently connecting. In the absence of a bulk system solution, this will significantly increase the amount of time the area is subjected to lower reliability and unable to meet the ORTAC reliability standards.

5.2 Windsor-Essex Demand Scenarios

As noted above, the primary driver of load growth for the overall region is expansion of the agricultural industry in the Kingsville-Leamington area. Demand forecast scenarios were developed based on different outlooks for growth in the Kingsville-Leamington area. While historically summer peaking, the load in the Kingsville-Leamington area is forecast to transition to a winter peaking load, due to the use of artificial crop lighting in winter months. As a result, the overall peak for the Windsor-Essex Region is also forecast to become a winter peak in the near-term.

Three scenarios were developed to represent the load growth forecast specific to the Kingsville-Leamington area.[7] Load growth was assumed to be all load that is supplied or will be supplied from the new Leamington tap line, constructed as part of the SECTR project, as well as any future growth forecast for the geographic area. Inputs to the forecast included:

- Customer connection request information received from the LDCs in the area (primarily Hydro One Distribution, as most of the new load is in its service territory), including:
  - Customer location,
  - Requested capacity in each month of the year over a five-year horizon for load to materialize, where available, and
  - Crop type (vegetable or cannabis);
- Historical acreage expansion rates for vegetable greenhouse growers in the area obtained from the Ontario Greenhouse Vegetable Growers Association
- Information received from connection applicants who have submitted, or indicated a desire to submit, requests for SIAs in the Kingsville-Leamington area; and
- Development of other infrastructure in the area that supports local greenhouse growth, such as:
  - Natural gas supply reinforcement projects, specifically the Kingsville gas pipeline reinforcement project scheduled to be completed this year,[8] and

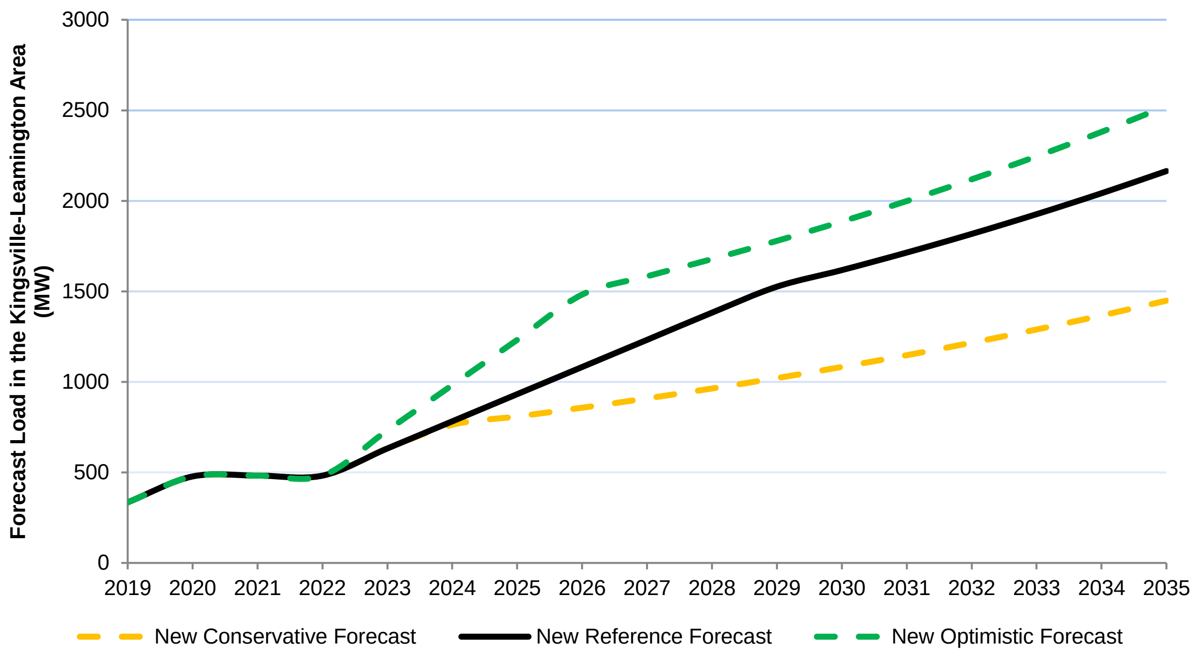
[7] The Kingsville-Leamington forecast in Figure 4 does not include the existing or forecast load supplied at Kingsville TS (up to the station's equipment rating). However, there is the potential that, after system reinforcements, some of the forecast load for the Kingsville-Leamington area could be supplied from the Kingsville TS site if enhancements were made to the existing station and/or its connection point.

[8] The IESO is also aware of Enbridge's planned expansion in the Dresden area. This will impact future studies for the electricity needs in the east of Chatham area.

- Municipal utility plans, specifically water and sewer system projects and road improvements undertaken by both the municipality of Leamington and town of Kingsville.

Based on the forecast inputs, three scenarios were developed specific to the Leamington-Kingsville area. All three scenarios are based on fufilling the LDCs' existing queue of customer connections, but assume different rates at which new loads may connect. The three forecast growth scenarios (conservative, reference, and optimisitic) are presented in Figure 4.

Figure 4: Winter Peak Forecast Scenarios for the Kingsville-Leamington Area



For the purpose of assessing incremental need for the area, the proposed switching station at the Leamington Junction is assumed to be in place. The switching station relieves the need for interim measures and allows additional load connections to be accomodated up to the capability of the bulk system to supply. Note that for all scenarios, the load forecast plateaus until 2022, after which the switching station is presumed to be in-service.

The *conservative scenario* assumes that after the Leamington switching station is built, the customers that have applied for an SIA, as well as those that have given a strong indication that an SIA application is imminent, are connected. Once the capacity at these facilities has been fully utilized, load is forecast to continue to grow at 6% per year,[9] reflecting historical acreage

[9] Based on the historical rate of under-glass greenhouse acreage expansion in the Leamington area, according to the Ontario Greenhouse Vegetable Growers Association.

expansion and assuming that the ratio of lit to unlit acreage will remain the same from that point forward until the end of the forecast period.

The *reference load scenario* assumes that after the Leamington switching station is built, the customer connections are addressed at a rate of 150 MW per year. This growth is informed by the rate at which LDCs are proposing to connect customers to the existing and expanded Leamington TS #1. Once the full queue of customers has been connected, load is assumed to grow at 6% per year until the end of the forecast period.

The *optimistic scenario* assumes that the construction of the Leamington switching station is followed by an aggressive build out of transformer stations and distribution lines with the transmitter and LDCs building facilities in parallel. This rapid construction will allow customers to be connected at an increased rate after 2022, addressing load connections at a rate of 250 MW per year. Once the full queue of customers has been connected, load is assumed to grow at 6% per year until the end of the forecast period.

The adoption of articifical crop lighting means that the energy profile for load in the Kingsville-Leamington area differs significantly from the rest of the Windsor-Essex Region and the province as a whole. Working with LDCs and members of the greenhouse community, the IESO developed a load shape for the greenhouse load to more accurately model the coincident Windsor-Essex area peak, as well as the region's hourly energy needs.

Using this load shape information, both summer and winter peak demand and energy forecasts for the broader Windsor-Essex Region were developed. This information is presented in Figure 5 and Figure 6, for the winter peak demand forecast and annual energy demand forecast, respectively.

Figure 5: Forecast Scenarios for Windsor-Essex Region Winter Peak Demand

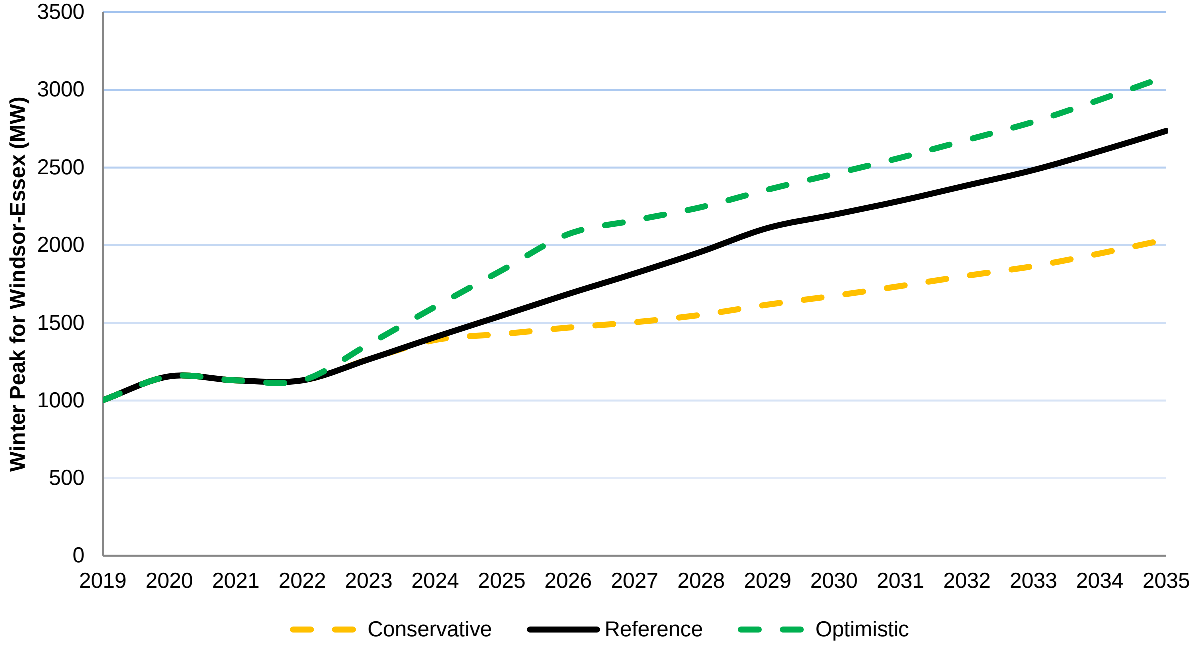
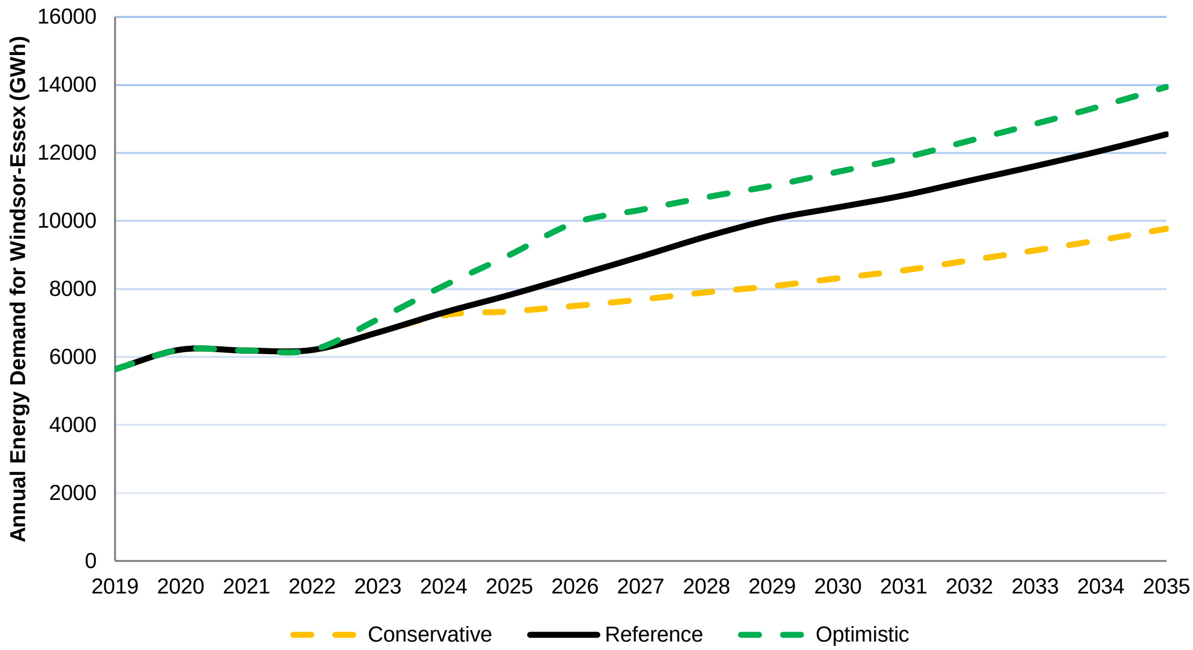


Figure 6: Forecast Scenarios for Windsor-Essex Region Annual Energy Demand



6 Supplying Windsor-Essex Demand

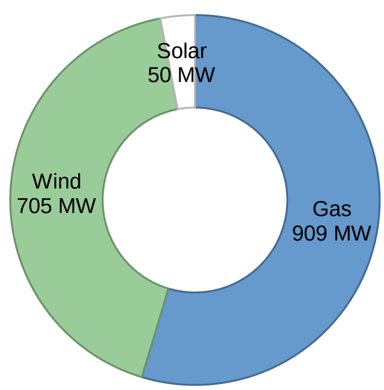
The Windsor-Essex Region is supplied by a mixture of internal resources (generation connected within Windsor-Essex) and external resources (generation located outside of Windsor-Essex accessed through transmission infrastructure).[10] The existing 230 kV network through the region provides Windsor-Essex with supply from the rest of Ontario, particularly the wind and gas generation resources located east of Chatham. It also offers a strong link with Michigan, allowing for imports and exports to flow through the region. Significant transmission connected generation resources located within the Windsor-Essex region, are also connected to both the 230 kV and 115 kV systems. The majority of the generation capacity in the region is located close to the city of Windsor.

The characteristics of these internal and external resources are discussed in further detail in sections 6.1 and 6.2.

6.1 Windsor-Essex Internal Resources

The Windsor-Essex Region's internal transmission connected resources currently comprise a significant amount of installed gas generation (including a large combined-cycle plant and a number of combined heat and power generators), a number of wind generators, and a large solar installation. These resources represent a combined total of 1,664 MW of installed generation capacity. Figure 7 shows the installed transmission connected resource mix in the Windsor-Essex Region in 2020.[11]

Figure 7: Installed Resources in the Windsor-Essex Area for 2020 by Resource Type



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

[11] The region also has a significant number of distribution connected resources, mainly wind and solar. The Kingsville-Leamington area also benefits from a number of smaller distribution connected combined heat and power generators. The impact of these distributed resources was also modelled in the study.

6.2 External Resources to Supply Windsor-Essex

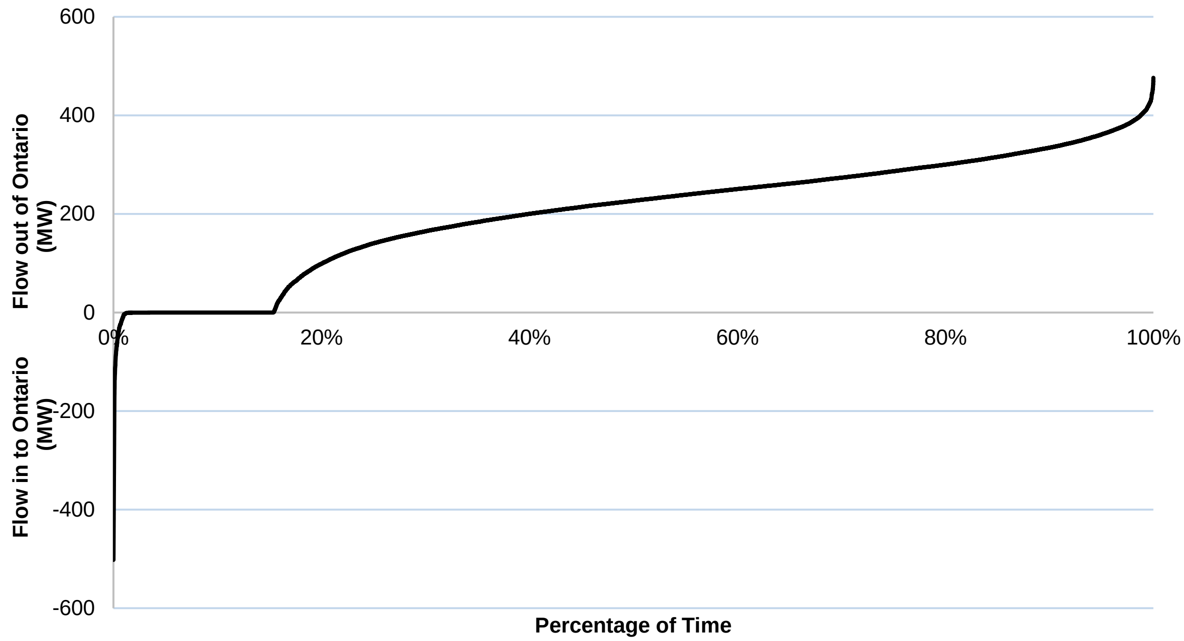
Supply to the Windsor-Essex Region is also provided by flow on the "West of Chatham" interface, defined as the four existing 230 kV transmission circuits that connect Keith TS and Lauzon TS in the region to Chatham SS in the east, providing supply from broader provincial resources.

Currently, the planning limit of this interface is 920 MW in the winter and 730 MW in the summer. The interface is limited by the loss of the 230 kV multi-circuit line C21J/C23Z, which connects Chatham SS to Keith TS and Lauzon TS, respectively. The recommended switching station at the Leamington Junction, while primarily required for increasing the capability to connect more load in the Leamington area, increases the transfer limit of the West of Chatham interface to 1,100 MW in the winter and 990 MW in the summer. With the switching station in place, the most limiting contingency is still the loss of 230 kV circuits C21J/C23Z and overloading the remaining circuits from Chatham SS to Keith TS and Lauzon TS.

The Windsor-Essex Region is also interconnected with Michigan at Keith TS by the J5D 230 kV interconnection line (Windsor to Detroit).[12] Currently, the interconnection between Ontario and Michigan supports import and export trade via the Ontario and Michigan real-time energy markets. In the future, with the implementation of the ICA, it may support capacity-backed imports or exports. Additionally, the J5D interconnection provides significant post-contingency support to the area through imports, which is used to increase transfer limits pre-contingency. While the entire Ontario-Michigan interface has a combined capability of 1,750 MW in the winter and 1,700 MW in the summer for both imports and exports, the tie located in the Windsor-Essex region is limited to approximately 400 MW. Figure 8 shows the recent historical flows on the intertie circuit. Phase-shifters on all the Ontario-Michigan interconnections, including J5D, control real-time flows across this major interconnection.

[12] The intertie circuit in the Windsor-Essex area that connects to the Michigan system is one of four circuits that interconnect Ontario and Michigan. The other three connection points are located in the Lambton and Sarnia areas.

Figure 8: Cumulative Distribution of Historical Flows on J5D Interconnection (2015-2018)



The Ontario-Michigan interface is subject to "loop-flows," which represent unscheduled flows that naturally occur, influenced by the dispatch of generation (within and external to Ontario), load levels and the configuration of the interconnected network. The IESO operates to control this to within +/-200 MW for the entire interface, but at times a portion of these loop-flows cannot be controlled. This means that the intertie circuit is likely subject to some amount of loop flow at any given time.

The current Ontario resource mix and loop flows, drives a substantial amount of export flow on this intertie - actual flow exceeds 200 MW from Ontario to Michigan 60% of the time, with export flows exceeding 350 MW typically 20% of time.

6.3 The Need for Additional Supply West of Chatham

The IESO has conducted an assessment of the system's capability to adequately supply the Windsor-Essex Region. Planning criteria were applied in accordance with North American Electric Reliability Corporation standards and the Northeast Power Coordinating Council reliability directories to determine system capacity needs. In the context of the bulk system, adequacy is defined as the ability to supply regional demand, while respecting transfer capability limits across the bulk system and interconnections.

This assessment considered both the contribution of existing internal generation and resources external to the area, and assumed the Leamington switching station was in place to facilitate further load expansion. A number of key sensitivities were considered to determine the potential impact on the magnitude and timing of the need for additional supply capability.

The analysis of system need also looked at scenarios related to maintaining bulk system capability, including the interchange capability between Ontario and Michigan. As a base case the study assumed this interchange path would be maintained. Scenarios where only half the interchange capability was maintained were also investigated to better understand the ability of the system to accommodate more aggressive growth scenarios.

The internal and external resources, and associated sensitivities, were modelled for the three demand scenarios. The ability for available resources to meet system needs was evaluated based on a capacity assessment, as well as an unserved energy assessment using UPLAN.[13]

Sections 6.3.1 and 6.3.2 present the results of the capacity and energy analysis in further detail.

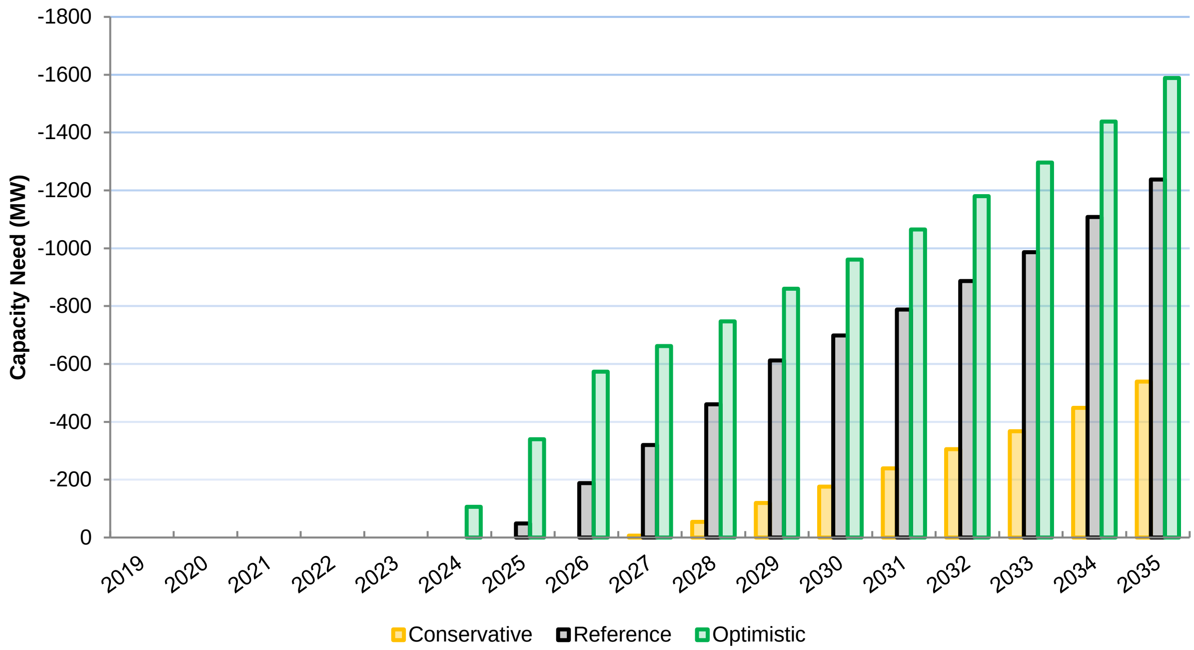
6.3.1 Capacity Adequacy Requirement

The IESO used a deterministic approach to evaluate the need for additional capacity in the Windsor-Essex Region. This approach considered internal resources based on their established capacity factors, and external resources based on the planning limit of the West of Chatham interface.

Based on this assessment, a capacity need of 49 MW begins to emerge in 2025 and increases to 188 MW by 2026 (under the reference load growth scenario). This capacity need continues to grow over the long-term and greater divergence is seen between the load growth scenarios, with over double the need seen under the reference load growth scenario compared to the conservative load growth scenario by 2035 (1,238 MW versus 539 MW). Figure 9 shows the winter capacity need for all three load growth scenarios, assuming interchange capability is maintained.

[13] UPLAN is a production cost modelling tool. UPLAN was also used to simulate and evaluate overall system production costs for the options compared in this analysis.

Figure 9: Winter Capacity Need for the Three Growth Scenarios



While the capacity need is predominantly a winter one, a summer capacity need also emerges under all forecast growth scenarios (as early as 2027 under the reference forecast and as late as 2032 under the conservative forecast).

6.3.2 Energy Requirement

The expected energy requirement was determined using the energy forecast for the three load scenarios, the supply capability of local generation and the capability of the existing West of Chatham interface (less the portion for maintaining interchange capability with Michigan).

These system conditions were modelled in UPLAN to evaluate both the yearly unserved energy profile without any system reinforcements and the incremental amount of generation already located in the region that was required to be dispatched due to local transmission congestion to meet local needs.[14] To establish the unserved energy profile, UPLAN dispatches available resources to serve the load while respecting the transfer limit of the West of Chatham interface, as discussed in section 6.2, and incorporating the probability of forced and planned generation outages. Figure 10 presents the yearly unserved energy in this region for the three demand growth scenarios. While the absolute amount of unserved energy for each year is presented, the

[14] Note, according to proposed changes under the IESO's Market Renewal Program, locational marginal pricing will more transparently reflect local area constraints, resulting in higher local pricing in areas where load supply is impacted by transmission congestion.

maximum hourly unserved energy and the number of consecutive hours of unserved energy were also used to inform the development of options to address the need.

Figure 10: Unserved Energy for the Three Growth Scenarios

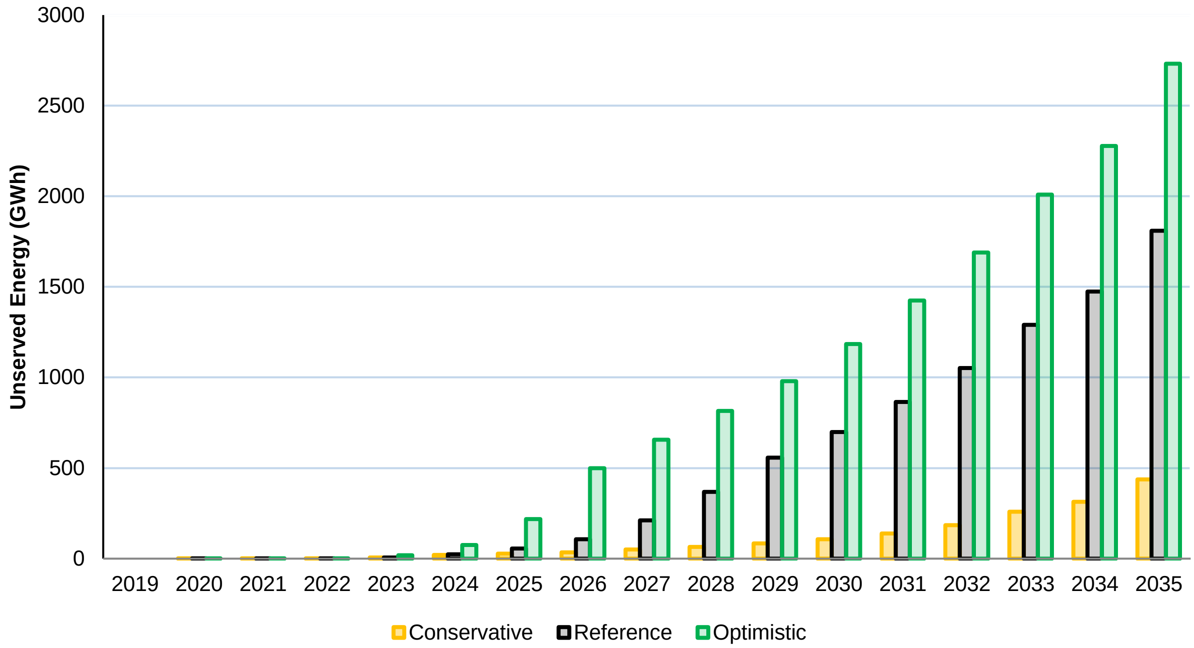


Figure 11 and Figure 12 present the unconstrained flow across the West of Chatham interface for the year 2026 along with the existing westbound interface limit (less the portion for maintaining interchange capability with Michigan). This provides an indication of the number of hours the West of Chatham interface is congested and generation located in the area is relied on to meet local needs, as well as hours when dispatching all local generation may be insufficient to meet the Windsor-Essex Region's needs (i.e., when the capacity need arises).

Figure 11: Unconstrained Flow Across the West of Chatham Interface for Winter 2026

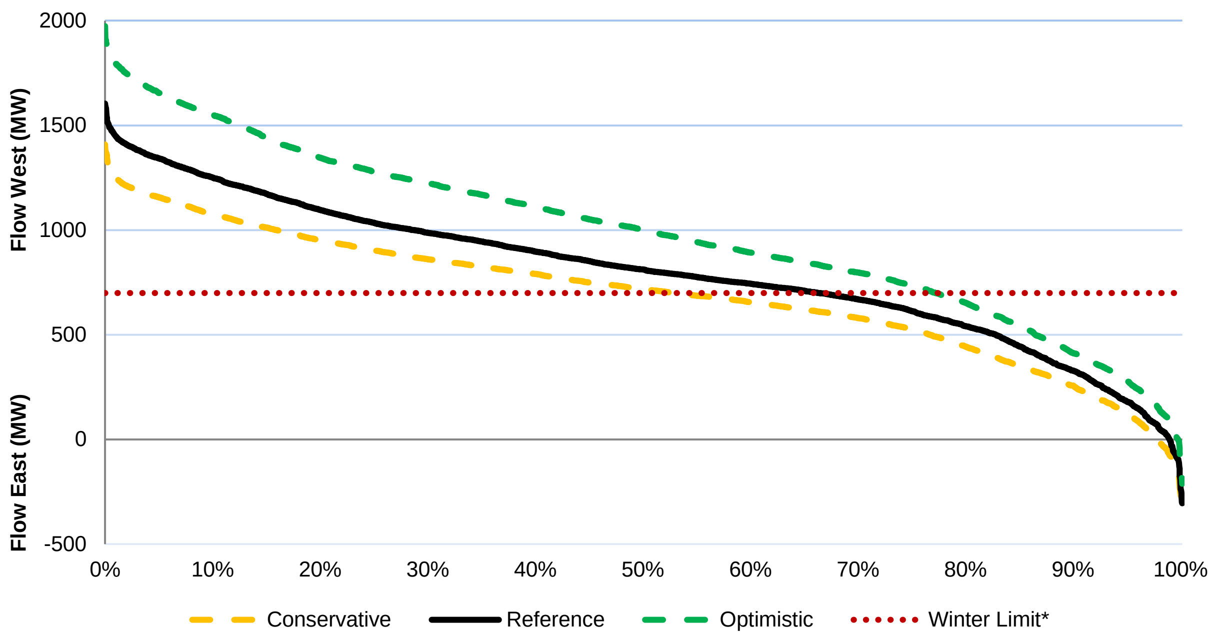
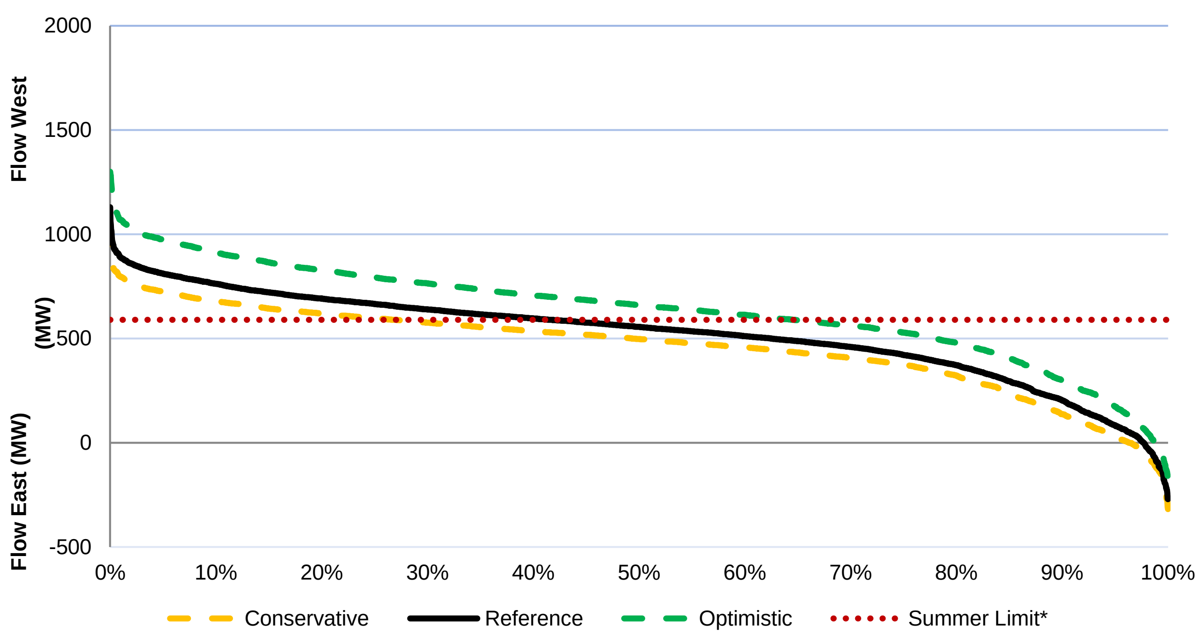


Figure 12: Unconstrained Flow Across the West of Chatham Interface for Summer 2026



The frequency with which resources in the Windsor-Essex Region may be used to relieve congestion on the West of Chatham interface increases as load in the region grows. For the year presented in Figure 11 and Figure 12, looking at the conservative load growth scenario, there is westbound congestion on the West of Chatham interface for approximately 40% of hours and, in approximately 10% of those hours, generation within the Windsor-Essex region is insufficient to meet demand, resulting in unserved energy events.[15] While the majority of unserved energy events occur in the winter months, as load grows, unserved energy events are also occurring in the summer months.

7 Analysis of Alternatives to Meet Supply Needs West of Chatham

This study compares the two lowest cost alternatives to meeting the identified mid-term supply need west of Chatham, assuming that the Leamington switching station is in place in 2022 and existing registered generation continues to be available. These options are described below:

1) **Reinforce the existing West of Chatham interface** – In this option a new 230 kV double circuit transmission line from Chatham SS to the switching station at the Leamington Junction forms a second stage of transmission development in the region. The approximately 50-km transmission line would increase the West of Chatham transfer capability to 1,500 MW.
2) **No transmission expansion west of Chatham** – In this option, all the identified capacity and energy needs are met through the addition of the least-cost resource alternative. After an assessment of the capabilities and cost of potential resources, a new natural gas-fired simple cycle gas turbine ("SCGT"), located west of the switching station at Leamington Junction was identified as the lowest cost resource alternative capable of supplying the magnitude of energy and capacity required. The initial stage of generation considered in this analysis included 400 MW in the mid-2020s.

Note that in Option 1, the total West of Chatham interface capability achievable with a new transmission circuit from Chatham SS to the switching station at the Leamington Junction is 2,050 MW of winter capability. However, the full transfer capability is restricted by transmission limitations from east and north of Chatham, i.e., from London or Sarnia.[16]

In Option 2, additional resource alternatives were considered. Significant demand response is currently infeasible since the risk to disruption of greenhouse crop growth cycles, the primary large load customers in the area, was determined to be prohibitive at this time.[17] Other generation types were considered (i.e., wind, solar, storage, combined cycle gas turbine),

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[15] This is on an annual basis, i.e., it. includes both the summer and winter hours from Figure 11 and Figure 12.
[16] Any system changes east of Chatham including new load connections could impact the capability of the proposed West of Chatham interface reinforcement.
[17] Use of demand response, primarily to meet local needs, is explored in further detail in the IRRP for the Windsor-Essex Region.

however the profile of energy required to meet this need made these options less cost-effective compared to a SCGT.

The assumptions and results from the economic analysis comparing these two options are presented in section 7.1. To be prudent, the IESO considered system needs for all demand growth scenarios; however, the analysis focused on the investments needed to meet near- and mid-term needs while preserving cost-effective options for meeting the potential mid- to long-term requirements based on the demand growth scenarios studied. To account for the risk that arises from demand growth in the region being driven by a single sector, the IESO will continue to monitor long-term growth west and east of Chatham and further refine the scoping of options east of Chatham prior to proceeding with any additional stages of transmission or generation reinforcement beyond what is outlined in section 8. As the IESO's Market Renewal Program is implemented, it is also expected that more transparent price signals (e.g., locational marginal prices reflecting transmission congestion) can help drive market activities in the region which can contribute to addressing the region's mid- to long-term needs.[18]

In addition to the NPV cost difference between the options, the IESO's analysis discusses risks associated with the generation alternative that may result in implementation difficulties or unanticipated costs.

7.1 Cost-Effectiveness Comparison of Generation and Transmission Alternatives

The IESO compared the NPV of total costs for a transmission reinforcement west of Chatham to the least-cost resource alternative, a new SCGT. This economic evaluation was based on cost estimates for similar-sized resources. Sensitivity analysis was conducted to test the robustness of the results under a variety of conditions. Among the tested sensitivities were the three demand growth scenarios, ranges in the cost of generation and transmission, and other cost related assumptions.

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

- The NPV of the cash flows is expressed in 2019 CAD.
- The NPV analysis was conducted using a 4% real social discount rate. Sensitivities at 2% and 8% were performed. An annual inflation rate of 2% is assumed.
- The life of the station upgrades was assumed to be 45 years; the life of the line was assumed to be 70 years; and the life of the generation assets was assumed to be 30 years.

[18] More information on the IESO's Market Renewal Program can be found here: http://www.ieso.ca/en/Market-Renewal

A capital injection of 20% of the initial capital for the SCGT is assumed to occur in year 21.

- An SCGT was identified as the least-cost resource alternative. The estimated overnight cost of capital assumed is about $780/kW (2019 CAD), based on escalating values from a previous study independently conducted for the IESO.
- The reference demand forecast is presented in section 5.2. Sensitivities to test the impacts of the conservative and optimistic growth scenarios on the NPV were performed. Once the need in each scenario surpassed the capability of the solutions being evaluated (i.e., 400 MW), the demand was flat lined for the purposes of the production cost analysis.
- The existing supply resources described in section 6 were reflected in the analysis.
- The transmission cost is assumed to be $270M (2015 CAD), informed by the 2015 SECTR cost estimate in the Leave to Construct application evidence on file with the Ontario Energy Board. A 50% contingency was assumed for the purpose of this analysis.
- A sensitivity of +/- 20% was assessed on the capital and ongoing fixed costs for generation.
- The NPV study period extended from the start of 2026, the year that either option would need to be in service, to the end of 2095, when a transmission asset replacement decision would be required.
- Natural gas prices were assumed to be an average of about $4/MMBtu throughout the study period.
- 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 cost of constraining the generating alternative to produce energy for a local need versus the cost of system supply was considered.

Comparing the required initial stage of transmission reinforcement to the generation alternative, the transmission option results in net present cost savings of approximately $500M for supplying load under reference load growth assumptions.

For all load growth scenarios considered in the analysis, additional system reinforcements would be required in the mid-term or in tandem with the next stage of reinforcement in order to maintain system reliability. Studies of these scenarios showed that transmission still offered an overall lower net present cost compared to generation.

These results indicate that transmission reinforcement is the most economical next stage of bulk system reinforcement and provides the basis to meet long-term needs in the most cost-effective way for the various load growth scenarios considered.

A reinforcement of the transmission system west of Chatham would provide additional benefits beyond meeting the reliability requirements of the broader Windsor-Essex area, which are unique to a transmission solution. Transmission reinforcement would provide system flexibility, relieve congestion to provide access to lower cost provincial generation and improve the economic dispatch of local resources to supply needs, decrease losses along the West of Chatham interface, and decrease exposure to local generation and transmission outages.

The IESO's future capacity auctions are designed to meet system resource adequacy needs, and while local generation could contribute to the overall provincial capacity need, its ability to do so is limited by the existing transmission infrastructure in the West of London area. For example, limitations on the FETL interface would significantly restrict the amount of capacity that can be transferred out of the area (or that would be able to compete in the auction).

However, a purely cost-based analysis of the local generation option potentially overestimates the generation cost, since it does not account for the contribution of this resource to meeting the forecast provincial capacity need. A sensitivity analysis comparing the cost of the transmission to the generation alternative while varying the provincial capacity contribution and the capacity value of the new SCGT yielded the same preferred solution. Assuming a system capacity value of $125/kW-year, the generation option only starts to become a viable economic alternative when more than 60% of the generator's capacity is considered deliverable to contribute to the overall provincial capacity need.

For generation to be technically capable of meeting the magnitude and timing of the need, a large gas facility would be required; at the same time options to site a facility of that nature are limited, resulting in very specific project requirements. In terms of siting, locating generation at the new switching station would be optimal for the bulk system. However, given the prevalence of agriculture in Essex county, siting and zoning approvals may be difficult. A more likely siting option would be the Windsor area, where gas infrastructure and existing generation are already in place. In any case, environmental approvals and permitting would be lengthy.

A proponent's choice of any location west of Chatham SS could also require new or reinforced transmission infrastructure to ensure the installed generator is able to meet the identified need (e.g., potential reinforcement from Windsor to the Leamington Junction may be required if generation were located in the Windsor area). These additional costs were not included in the economic evaluation.

Finally, in terms of the resource solution itself, a SCGT was determined to be the lowest-cost resource alternative for a next phase of system reinforcement. The selection of this option for comparison to the transmission alternative did not account for potential operational issues that may arise during planned maintenance activities or forced outages to the unit. For reliability purposes, diversification of this resource would be preferred, which would result in higher costs, due to loss of economies of scale, not accounted for in this analysis.

8 Conclusions and Recommendations

Early within this bulk planning process, the urgent need for additional electricity supply capacity to supply load to the Leamington area was identified. To address the near-term supply needs in the area west of Chatham, the IESO determined that the need for a new switching station at the Leamington Junction with an in-service date of 2022 was common to all scenarios considered. As a result, the need for a new switching station at the Leamington Junction was triggered on January 31, 2019, when the IESO issued a hand-off letter to Hydro One requesting that development work for this switching station be initiated.

To further address near- to mid-term supply needs in the area west of Chatham, the IESO recommends proceeding with a second stage of transmission reinforcement: a new 230 kV double circuit transmission line from Chatham SS to the new switching station at the Leamington Junction, with an in-service date prior to the winter of 2025/2026.

The IESO will continue to monitor the progress of load and generation connections in the area while studying future system needs east of Chatham. Future stages of system reinforcement will be triggered as required. As the Market Renewal Program is implemented, it is also expected that more transparent price signals (e.g., locational marginal prices reflecting transmission congestion) can help drive market activities in the region, contributing to addressing the region’s mid- to long-term needs.