Northern Ontario Bulk Study: North-South Transmission Reinforcement Plan

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List of Abbreviations

APO	Annual Planning Outlook
BES	Bulk Electric System (NERC)
BPS	Bulk Power System (NPCC)
CCGT	Combined Cycle Gas Turbine
CDM	Conservation Demand Management
CLAN	Claireville North
CLANE	Claireville North plus Orangeville and S2S East
CLAS	Clarieville South
DER	Distributed Energy Resources
DG	Distributed Generation
DSC	Distribution System Code
EAF	Electrical Arc Furnaces
EWTE	East West Tie East
EWTW	East West Tie West
ExV	Claireville TS x Essa TS 500kV Circuits
FIT	Feed-in Tariff
FETT	Flow East Towards Toronto
FN	Flow North
FS	Flow South
GS	Generation Station
IRRP	Integrated Regional Resource Plan
I/S	In Service
kV	kilovolt
LAC	Local Advisory Committee
LDC	Local Distribution Company
LMC	Load Meeting Capability
LTIDRDO	Long-Term Industrial Demand Response During Outages
LTE	Long-Term Emergency
LTR	Limited Time Rating
MISSE	Mississagi East
MISSW	Mississagi West
MTS	Municipal Transformer Station
MVar	Mega Volt Ampere Reactive
MW	Megawatt
NERC	North American Electric Reliability Corporation
NPCC	Northeast Power Coordinating Council
NE	Northeast
NPV	Net Present Value
NW	Northwest
OEB	Ontario Energy Board

ORTAC	Ontario Resource and Transmission Assessment Criteria
O/S	Out of Service
RIP	Regional Infrastructure Plan
SIA	System Impact Assessment
SS	Switching Station
STE	Short-Term Emergency
TFS	Technical Feasibility Study
TS	Transformer Station
TSC	Transmission System Code
UCAP	Unforced Capacity

Disclaimer

1 Executive Summary

This document describes the results of the Northern Ontario Bulk Study: North-South Transmission Reinforcement Plan ("the Plan") that the Independent Electricity System Operator (IESO) has undertaken to assess the reliability of the bulk transmission system that connects Northern[1] and Southern Ontario. The bulk transmission system connecting Northern and Southern Ontario primarily consists of two 500 kV circuits and one 230 kV circuit from Sudbury to Barrie and Laurentian Hills, respectively. The Plan was developed to support growing electricity demand in Northern Ontario, driven by both economic development and organic demand growth. It also enables the siting of additional generation in the region by increasing transfer capability, helping Ontario meet its future energy and capacity needs, as identified in the 2024 and 2025 Annual Planning Outlook.[2]

This Plan provides recommendations to address electricity needs over the next 20 years. The identified needs are based on the demand growth anticipated in Northern Ontario and the capability of the existing transmission system, as evaluated using IESO's Ontario Resource and Transmission Assessment Criteria (ORTAC), as well as reliability standards governed by the North American Electric Reliability Corporation (NERC) and the Northeast Power Coordinating Council (NPCC). The Plan's recommendations are informed by an evaluation of alternative options to meet identified needs, considering technical feasibility, reliability, cost, opportunities to maximize the use of the existing electricity system (where economic and feasible), and feedback from stakeholders.

There are several recent or ongoing transmission reinforcement projects in Northern Ontario, including:

- **Wataynikaneyap Transmission Project** – new single circuit 230 kV line from Dinorwic Junction near Dryden to Wataynikaneyap TS near Pickle Lake, as well as 115 kV remote connection circuits north of Pickle Lake and Red Lake (completed)
- **Waasigan Transmission Line** – new single circuit 230 kV transmission line from Dryden to Atikokan and a new double circuit transmission line from Atikokan to Shuniah near Thunder Bay (targeted in-service date 2025 to 2027)
- **East-West Tie Reinforcement** – new double circuit 230 kV transmission line from Shuniah near Thunder Bay to Wawa (completed)
- **Wawa to Porcupine Transmission Reinforcement Project** – new single circuit 230 kV transmission line from Wawa to Timmins (targeted in-service date 2030)
- **North Shore Link** – new double circuit 230 kV transmission line from Sault Ste. Marie to Wharncliffe (targeted in-service date 2029)

[1] For the purposes of this report, Northern Ontario is defined as the portion of the Power system North of Parry Sound and West of the Laurentian Hills area.

[2] Annual Planning Outlook

- **North East Power Line** – new single 500 kV transmission line from Wharncliffe to Sudbury (targeted in-service date 2029)

Taken together, these projects reinforce the bulk transmission system from Sudbury all the way to Dryden, supporting demand growth across the Northwest region, Sault Ste. Marie and Timmins area.

Electricity demand from the industrial sector in Northern Ontario is forecast to grow at a rapid pace, especially over the next 10 years, primarily driven by mining developments and electrification initiatives.

Long-term study results show that to meet this need, Northern Ontario will need to be a large importer of energy from Southern Ontario, putting upward pressure on several transmission interfaces across Northern Ontario, as well as some upstream transmission interfaces located in the South that help support northward flow conditions.

In response to this forecasted growth, the IESO performed a technical analysis to assess the capability of the transmission system between Northern and Southern Ontario to supply this growth while maintaining reliability. The analysis identified that the existing transmission system has insufficient capability to reliably supply forecasted demand in Northern Ontario. This need is primarily observed during overnight hours, due to how energy-limited hydroelectric resources in the North are dispatched to support Ontario system peaks while reducing output overnight to conserve water and make it available for the following day. This need will grow to include all hours of the day because of continuing demand growth in Northern Ontario and the potential decommissioning of ageing thermal generation plants.

To address this need, the Plan recommends:

- Implementing a new single circuit 500 kV series-compensated3 transmission line between Hanmer TS in Sudbury and Essa TS in Barrie (estimated length of ~270 km, cost of $1.4 billion to $1.6 billion,[4] and in-service date of 2032).
- Preserving future transmission options by beginning early development work on a possible second new 500 kV transmission line between Essa TS and Hanmer TS.
- Exploring strategic siting of cost-effective system generation in Northern Ontario, including baseload generation, where existing bulk transmission system capacity exists, to help defer the need for the second new 500 kV transmission line.

The recommended plan provides further benefits beyond accommodating forecast load growth (including a higher growth scenario). These additional benefits are summarized as follows:

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[3] Series compensation of a transmission line entails the incorporation of capacitors in series with the line to reduce its effective inductive reactance, therefore increasing the power transfer when limited by voltage issues. Series compensation does not increase power transfer limited by thermal issues. The Ontario transmission system currently has series compensation on two transmission lines, identified as X503E and X504E, which efficiently manage high power transfers between the northern and southern regions.

[4] Based on planning estimates, with an accuracy of –30% to +100%.

- Increase the power transfer capability from Southern Ontario to Northern Ontario by 1,500 MW,[5] accommodating higher growth scenarios
- Increase the power transfer capability from Northern Ontario to Southern Ontario by 1,000 MW, which will enable various types of supply resources, including variable/intermittent energy, peaking, baseload, and storage in Northern Ontario.
- Provide a foundation and advance key development work to help reduce lead time for further transmission system expansions when required in the future.

This report also identifies key transmission interfaces both North of Sudbury and South of Barrie that are being assessed through future bulk system plans to further enable economic development and siting of generation in Northern Ontario, including:

- The portion of the transmission system connecting the area North of Sudbury to the rest of Ontario. In 2022, the IESO recommended construction of a new transmission line between Wawa TS in Wawa and Porcupine TS in Timmins by year 2030 to support demand growth in both the Timmins area and in Northwestern Ontario. Additional demand growth emerging in the Timmins area, along with the potential development of large hydroelectric facilities North of Timmins will require additional transmission reinforcements. The IESO is conducting the North of Sudbury Bulk Study[6] to assess the need for further system enhancements in the area.
- The portion of the transmission system between the Barrie area and the GTA/Southwestern Ontario, as this interface plays a critical role in delivering power to and from the North-South interface. The IESO is conducting a South and Central Bulk Study[7] to examine long-term bulk system needs in the area. Before determining a long-term bulk plan for the area, the IESO is working with the transmitter to take early actions to strengthen this portion of the transmission system. This includes advancing end-of-life conductor replacements on the E8V and E9V 230 kV circuits between Orangeville TS in Orangeville and Essa TS in Barrie, using advanced, higher-ampacity conductors.

The IESO is currently in the process of several supply resource procurement programs including the Medium-Term Procurement 2, Long Term Procurement 2[8], and Long Lead Time Procurement There is potential for some of the longer term needs to be addressed via these mechanisms, deferring the need for the second additional 500 kV transmission line. The IESO will continue to monitor demand growth and resource procurements in Northern Ontario to determine future needs in Northern Ontario.

Given the timing and magnitude of the need, which is primarily driven by the load profile and the high-capacity factor of large industrial loads, the Non-Wires Alternative (NWA) analysis concluded that many types of resources would be infeasible to meet the need on their own, and were

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[5] The power transfer capability improvements shown reflect a transmission system with one new single circuit 500 kV transmission line.

[6] Northern Ontario Bulk Planning

[7] South and Central Bulk Planning

consequently screened out. This included a wide range of options, including natural gas, solar, wind, hydroelectric, biomass, hydrogen fuel cell, and storage. These options were unable to accommodate the forecasted electricity need, due to connection issues or a mismatch between the resource profile and the electricity need profile. These NWAs were screened out primarily for the following reasons:

- There would be challenges siting a significant amount of generation in Northern Ontario without additional local transmission.
- The net present value (NPV) cost of NWA options surpasses the cost of the transmission option of a single new 500kV circuit.

Transmission needs are projected to persist continuously throughout all hours of the day over the medium to long term. Addressing these anticipated needs through natural gas generation would require the gas plants to operate at all times, which is an undesirable outcome. This situation could potentially hinder economic development, due to the substantial cost associated with continuous operation of these units. Additionally, reliance on natural gas generation does not constitute a viable long-term strategy for reducing carbon emissions, contrary to the objectives of the Clean Electricity Regulations (CER) enacted under the *Canadian Environmental Protection Act*. These regulations establish a performance standard of 30 tonnes of CO_2 emissions per gigawatt-hour (T/GWh).

Engagement on the Northern Ontario Bulk Study was carried out throughout the plan's development, with three public webinars held in May, September, and November 2024.

The IESO will continue working with stakeholders and communities throughout the implementation of the Northern Ontario Bulk Study: North-South Transmission Reinforcement Plan.

2 Background and Introduction

Northern Ontario comprises two IESO electrical zones,[8] the Northeast (NE) and Northwest (NW) zones. These zones have large quantities of installed hydroelectric resources, which are complemented with smaller renewable and thermal resources. The total amount of installed generation capacity is significantly higher than Northern Ontario's peak demand. However, hydroelectric and other renewable resources are energy limited, and their generation output is variable in nature. As a result, the total available energy output from all northern supply resources is significantly less than the total energy demand when accounting for all hours.

The transmission system supplying Northern Ontario is connected to the Essa Zone via the Flow North (FN) / Flow South (FS) interface, which consists of two single circuit 500 kV series-compensated transmission lines between the Barrie area and the Sudbury area and a single circuit 230 kV transmission line between Mattawa and Laurentian Hills, as shown in Figure 2.1. The Essa Zone has a balanced resource mix of hydroelectric, renewables, and thermal generation resources that total less than the peak demand. The Essa Zone is connected to the Toronto zone and the Southwest Zone via the Claireville North plus Orangeville and S2S East (CLANE[9]) / Claireville South (CLAS) transmission interface. This interface consists of two single circuit 500 kV transmission circuits between Barrie and Woodbridge and a double circuit 230 kV transmission line emanating from Woodbridge and traversing through York region, a 230 kV double circuit transmission line between Barrie and Orangeville, and a single circuit 115 kV transmission line between Owen Sound and Stayner, as shown in Figure 2.2.

During periods of high generation output in the NE, NW, and Essa Zones, these interfaces support the transfer of excess generation to load centres in the Greater Toronto Area (GTA), while during periods of low generation output, these interfaces transfer power north to supply loads in Northern Ontario. Both interfaces are critical to the reliable supply of power to Northern Ontario.

Industrial load forms a large component of electricity demand in the North, particularly in the mining and mineral processing sub-sectors. Significant demand growth is forecasted throughout the study period, driven by electrification, mining, and industrial development. For example, the federal and provincial governments are providing support for decarbonization initiatives that would promote intensified electricity use. Furthermore, Ontario's Critical Mineral Strategy and economic development activities could also result in more investment in mineral exploration and development, driving further electricity demand growth. The aforementioned policies related to economic development and society's recognition of a need to decarbonize our economy have put an accelerated upward pressure on electricity demand growth in Northern Ontario and, therefore, a need to assess the ability to reliably supply demand north of these interfaces.

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[8] Visit the IESO's zonal map (https://www.ieso.ca/localContent/zonal.map/index.html) illustrating the 10 electrical zones.

[9] Historically, the CLAN interface was used, however, the CLAN interface does not account for power flowing on E8V, E9V, and S2S into the Essa Zone. Therefore, henceforward, the CLANE definition will be used in this report.

There are several recent or ongoing transmission reinforcement projects in Northern Ontario including:

- **Wataynikaneyap Transmission Project** – new single circuit 230 kV line from Dinorwic Junction near Dryden to Wataynikaneyap TS near Pickle Lake, as well as 115 kV remote connection circuits north of Pickle Lake and Red Lake (completed)
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Taken together, these projects reinforce the bulk transmission system from Sudbury all the way to Dryden, supporting demand growth across the Northwest region, Sault Ste. Marie, and the Timmins area.

The Minister of Energy has instructed the IESO[10] to assess known bottlenecks in the transmission system, including between Northern Ontario and Southern Ontario, to unlock opportunities for new nuclear, hydroelectric and renewable generation and support future demand growth. The IESO has also identified several successive generation procurement targets.[11] While the locations of potential supply resources have not been specified, congestion on the existing FS and CLAS transmission interfaces could inhibit the province's ability to add significant amounts of new generation in Northern Ontario, particularly during periods of high wind and solar output, combined with high hydroelectric production.

[10] https://www.ieso.ca/-/media/Files/IESO/Document-Library/corporate/ministerial-directives/Letter-from-the-Minister-of-Energy-20230710-Powering-Ontarios-Growth.ashx

[11] https://ieso.ca/-/media/Files/IESO/Document-Library/resource-eligibility/Evaluating-Procurement-Options-For-Supply-Adequacy.ashx

Figure 2.1| Geographic Diagram of the Flow North Interface

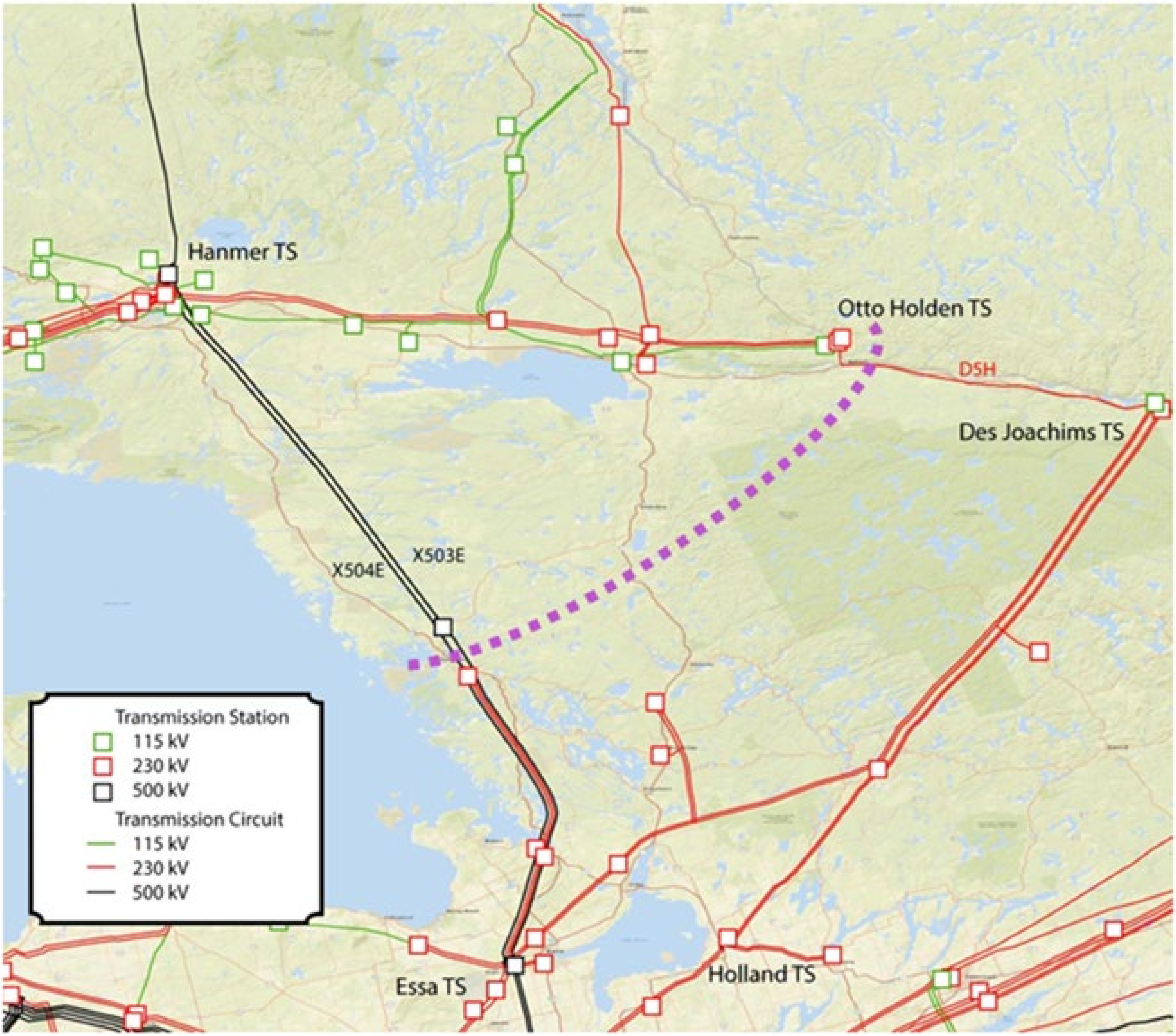
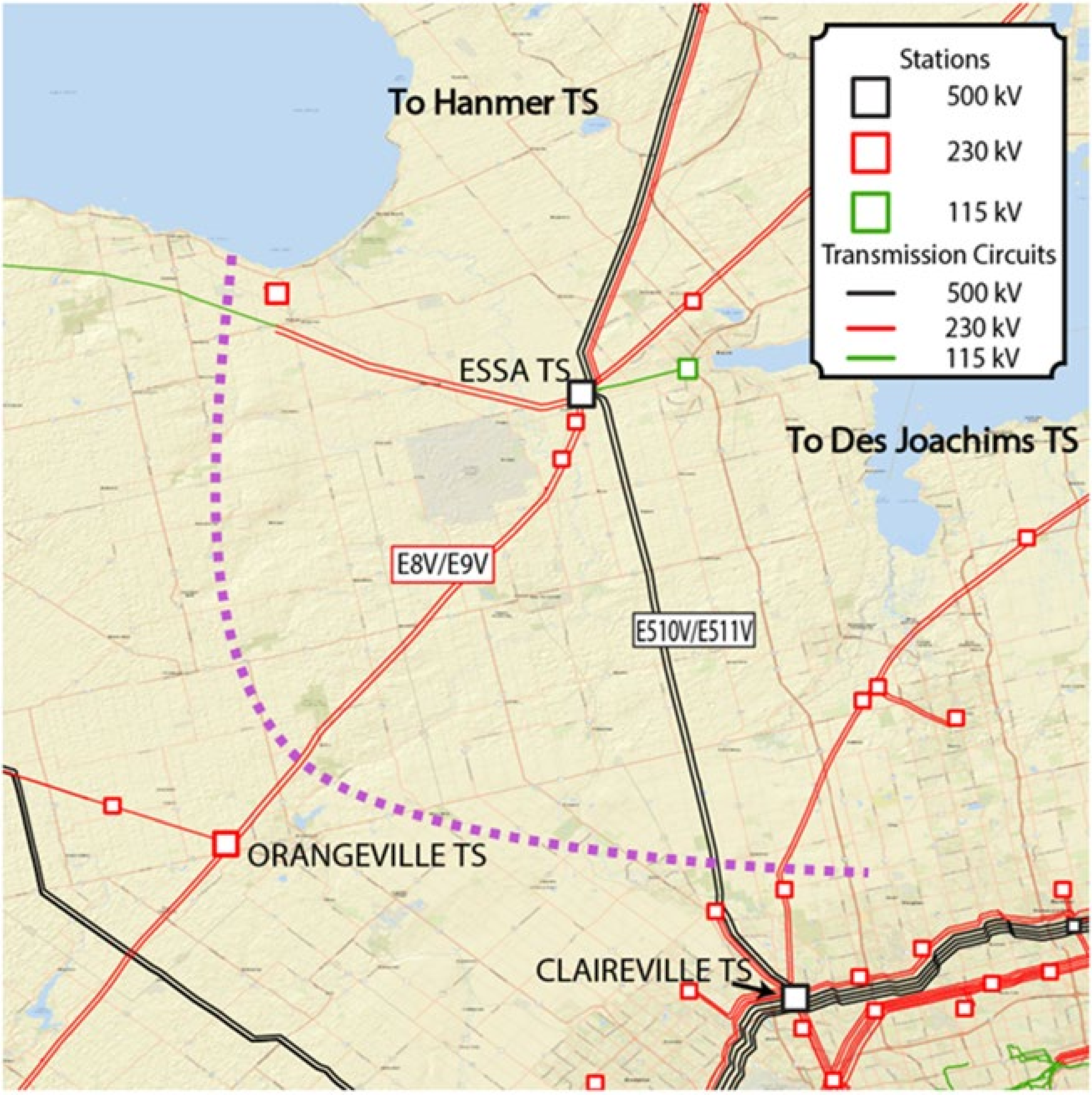


Figure 2.2| Geographic Diagram of the Claireville North Plus Orangeville and S2S East Interface



This report documents the inputs, methodology, findings and options evaluation performed for this study and provides recommended actions for the various entities responsible for plan implementation. It is organized into the following sections:

- Section 3 outlines the scope of this planning study.
- Section 4 highlights the demand forecast scenarios and considerations.
- Section 5 provides an overview of the existing supply to the focus areas.
- Section 6 provides an overview of the existing remedial action schemes in the focus area and their expected usage.
- Section 7 provides an overview of the criteria and methodology used in this assessment.
- Section 8 analyzes the FN and FS transmission system capability for the existing system, discusses the issues, and identifies the bulk system needs.
- Section 9 evaluates the options, including wires options and non-wires alternatives.
- Section 10 provides information on emerging generation opportunities.
- Section 11 provides details on additional emerging needs.
- Section 12 concludes the study findings and recommends a preferred solution.
- Section 13 describes the engagement activities to date.

3 Scope of Assessment

This bulk plan addresses the system security needs that arise in Northern Ontario due to anticipated industrial load growth and decarbonization. To develop the plan, the IESO performed a technical assessment to analyze the transfer capabilities of major transmission interfaces and identify bulk system needs north of the GTA. This assessment had two main objectives:

- Assessing the ability to reliably supply load North of the Barrie area, as per planning criteria established in Ontario Resource and Transmission Assessment Criteria (ORTAC), Northeast Power Coordinating Council (NPCC), and North American Electric Reliability Corporation (NERC) standards.
- Assessing how additional transmission reinforcements between Sudbury and the GTA reduce congestion and enable additional resources north of the Barrie.

The analysis was based on the transmission system configuration for the summer 2031 season and winter 2031/2032 season, reflecting the planned in-service dates of the Wawa to Porcupine Transmission Reinforcement, North East Power Line, and North Shore Link projects, along with the transmission system enhancements as listed in Appendix A.[12]

The focus of the assessment is to address the rapidly developing needs on the FN interface, followed by identifying any subsequent needs that may present on the CLANE interface. However, it is important to note that the CLANE interface has many interdependencies with ongoing regional plans in York Region, as well as interdependencies with the South and Central Bulk Plan. Therefore, this study will provide input to these ongoing studies and pending the output of those studies revisit any needs on the CLANE interface. It is also important to note that the demand and generation profiles for the Essa Zone must be accurately captured to ensure that any needs or recommendations with respect to FN consider the limitations of the transmission equipment in the Essa Zone, as the NE zone is radially connected to the Essa Zone.

The scope of the reliability assessment for FN transmission interface will be limited to the following scenarios:

- All transmission elements in-service
- Outage to one of the 500 kV circuits X503E or X504E

[12] Known system enhancements as of October 1, 2023 from various regional/bulk plans, as well as System Impact Assessment (SIAs).

Transfer capabilities for the CLANE transmission interface will be assessed for the following scenarios to determine any additional needs to inform the York Regional Plan and the South and Central Bulk Study:[13]

- All transmission elements in-service
- Outage to one of the E510V or E511V 500 kV circuits

The congestion study will be limited scenarios where all transmission elements are in-service:

- The timing and duration of planned outages should be coordinated with generation levels to reduce congestion and cannot be known for future time periods at this time.
- Forced outages are expected to occur infrequently, and typically last less than 72 hours, and therefore are not expected to cause significant congestion.

It is assumed that any new load or generation facility north of the FN interface would inherently require an independent assessment to determine what local transmission reinforcements would be required to support the connection of the facility. This bulk study assessment looks at the transmission needed on the North-South transmission interface to facilitate future transfers. Therefore, transmission needs north or west of Hanmer TS are outside the scope of this study and would be studied in further detail in subsequent bulk plans.

[13] https://www.ieso.ca/Sector-Participants/Engagement-Initiatives/Engagements/South-and-Central-Bulk-Planning

4 Demand Forecast

The IESO's bulk planning considers broad areas and growth factors, while remaining responsive to customer needs and policy decisions. Thus, the growth scenarios considered in this Plan were driven by economic development, policy, and governmental direction. Furthermore, the IESO's demand outlook considers:

Information received from those who have applied for an IESO System Impact Assessment (SIA)

- Information received by the IESO from potential connection applicants who have inquired about SIAs or feasibility assessments
- Regional Planning Forecasts
- IESO's 2023–2025 Annual Planning Outlook (APO)

As per the APO, the primary metal sub-sector is expected to grow robustly, with electrification already beginning and expected to materialize in the medium-term. In general, the industrial sector is expected to be influenced by emerging de-globalization trends, supported by various levels of government interested in increasing local industrial production capability and economic development, and interest in electrification and general carbon emissions reduction over the outlook period.

Electrical demand in the Essa Zone is a mix of residential, commercial and small industrial, while electrical demand in Northern Ontario is dominated by large, industrial customers and can fluctuate significantly in response to changing economic and market conditions. Considering the likelihood of identified projects proceeding, the following two demand outlook scenarios were developed to reflect the inherent uncertainties related to industrial development north of the FN and CLANE interfaces:

- The **Firm Demand Scenario** incorporates the already-existing loads, facilities for which an SIA has been completed, and the project has been committed.[14]
- The **Potential Growth Scenario** builds on the Firm Demand Scenario assumptions and includes additional large industrial projects for which an SIA or Technical Feasibility Study (TFS) has been completed (or is underway), but that have not yet been committed.

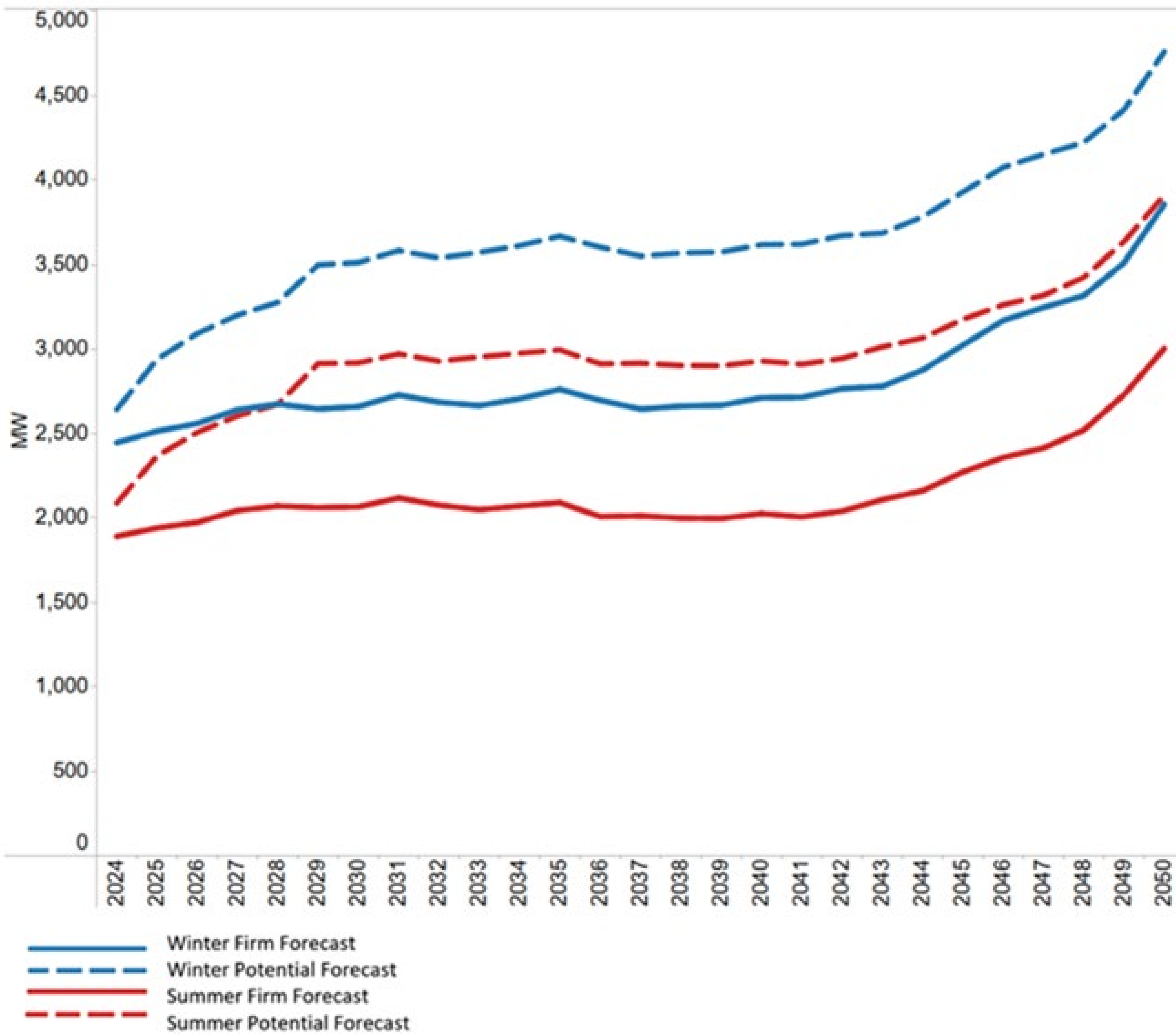
Throughout the planning and development of this bulk plan, the IESO held targeted public stakeholder discussions to help inform the electricity demand for the region. Section 13 provides additional details on the engagement activities for this study.

[14] As per IESO Market Manual Part 1.4 Connection Assessment and Approval

4.1 Demand Forecast North of the FN Interface

Figure 4.1 shows the year-over-year normal weather coincidental peak demand forecast for Northern Ontario (i.e., north of the FN interface). Forecasts are shown for both the summer and winter seasons and both the firm and potential forecast scenarios. It should be noted that the extreme weather demand and normal weather demand are nearly identical, which is due to the demand in the Northeast and Northwest zones being predominantly industrial.

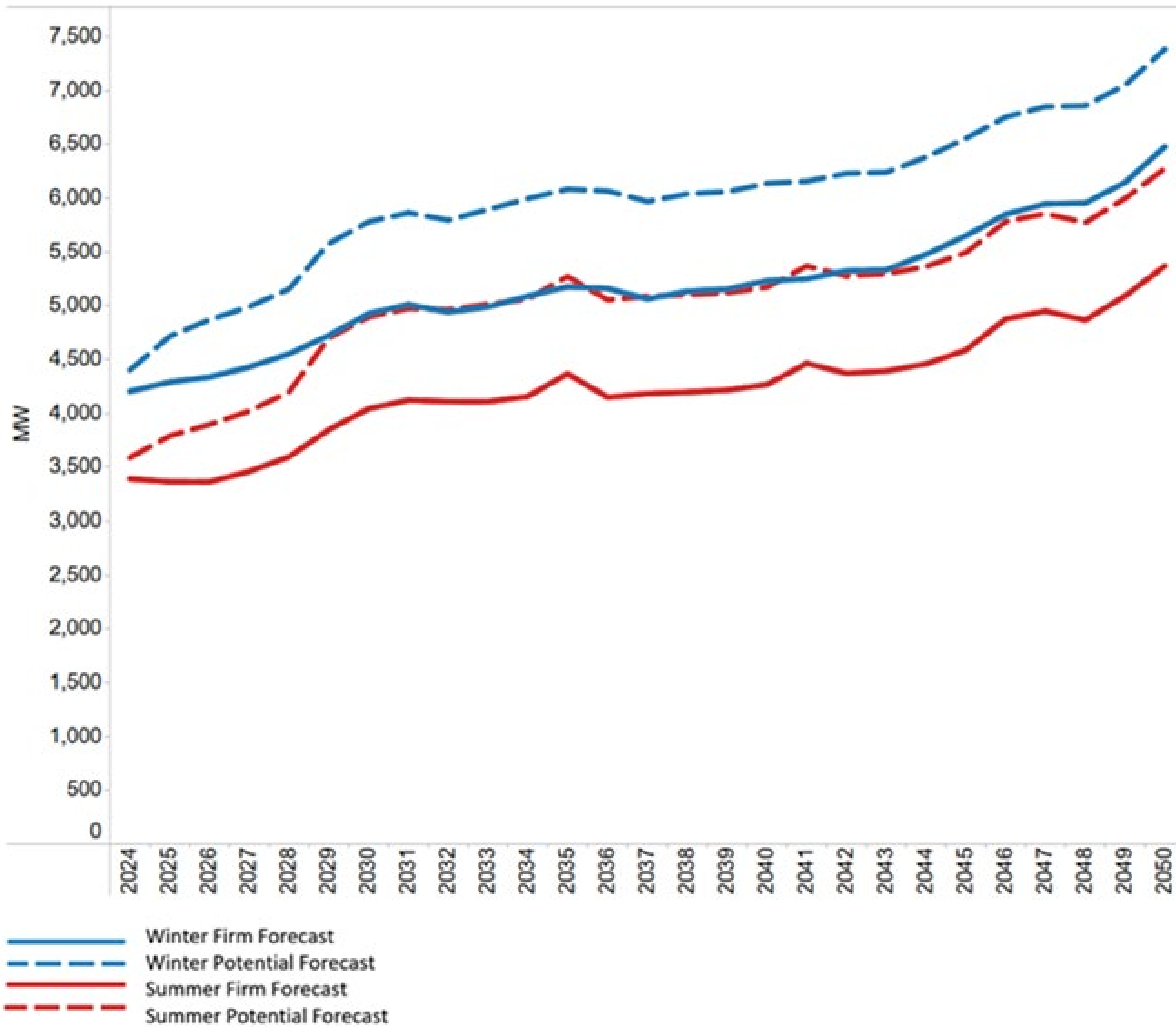
Figure 4.1| Peak Coincident Demand Forecast North of the FN Interface



4.2 Overall Demand Forecast North of CLANE Interface

Figure 4.2 shows the year-over-year normal weather coincidental forecast and normal weather demand forecast north of the CLANE interface. Forecasts are shown for both the summer and winter seasons and both the firm and potential forecast scenarios. It should be noted that the extreme weather demand and normal weather demand are nearly identical, which is due to the demand in the Northeast and Northwest zones being predominantly industrial.

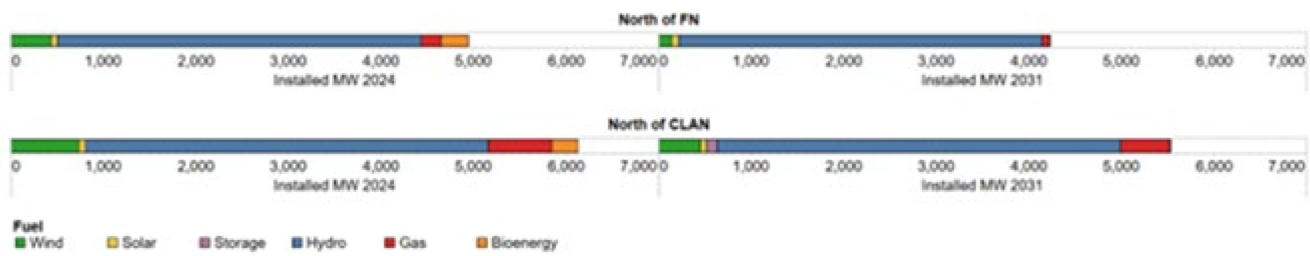
Figure 4.2| Peak Coincident Demand Forecast North of the CLANE Interface



5 Existing Supply

Figure 5.1 shows the changes in installed capacity of transmission connected supply resources under contract north of the FN and CLANE interfaces, between 2024 and 2031.[15] Distributed Energy Resources (DER) and load displacement resources are accounted for as part of the demand forecast.

Figure 5.1| Contracted Supply Mix in 2024 vs 2031



As of 2031, hydroelectric generation accounts for ~90% of the existing installed supply resources north of the FN interface and ~75% north of the CLANE interface. Most of the hydroelectric facilities in Northern Ontario are run of river, commonly referred to as peaking facilities, that have limited storage capability. The limited water storage, combined with variations in water conditions, result in large variations in energy production across the year.

To establish the required transfers and outlook for security of the transmission interfaces, dependable generation is assumed in accordance with the IESO's Transmission Security Outlook Methodology.[16] Energy-limited and intermittent resources are assumed to be at their historical generation levels, with availability of 98% of the time when all transmission elements are in-service, and 85% of the time when one transmission element is out of service. Non-energy-limited resources are at the seasonal installed capability. For the purposes of this assessment, all thermal resources are assumed available while under contract and unavailable thereafter, while renewable resources are assumed to be re-contracted. Table 5.1 provides the installed capacities of transmission-connected hydroelectric generation wind and solar for the NE+NW zones and for the Essa Zone, for the year 2031.

Figure 5.2 and Figure 5.3 provide the aggregated daily 98 percentile and 85 percentile generation profiles for resources north of the FN and CLANE interfaces, respectively, for the winter months and summer months. It is important to note that hydroelectric generation output varies across the day, with the output at its highest during system peak hours (evenings) and its lowest during system minimum hours (overnight). This difference is typically around 1,000 MW on average, with no solar

[15] As of October 1, 2023.

[16] https://www.ieso.ca/-/media/Files/IESO/Document-Library/planning-forecasts/apo/Dec2021/Transmission-Security-Methodology.ashx

generation output during overnight periods. This characteristic will play a key role when determining system needs.

Table 5.1| Transmission Connected Resources Total Installed Capacity By Area

Generator Type	MW
NE+NW Installed Hydro Capacity	3925
NE+NW Installed Solar Capacity	70
NE+NW Installed Wind Capacity	433
Essa Installed Hydro Capacity	429
Essa Installed Solar Capacity	0
Essa Installed Wind Capacity	300

Figure 5.2| Aggregated Daily 98 and 85 Percentile Generation Profiles for the NE+NW Zones

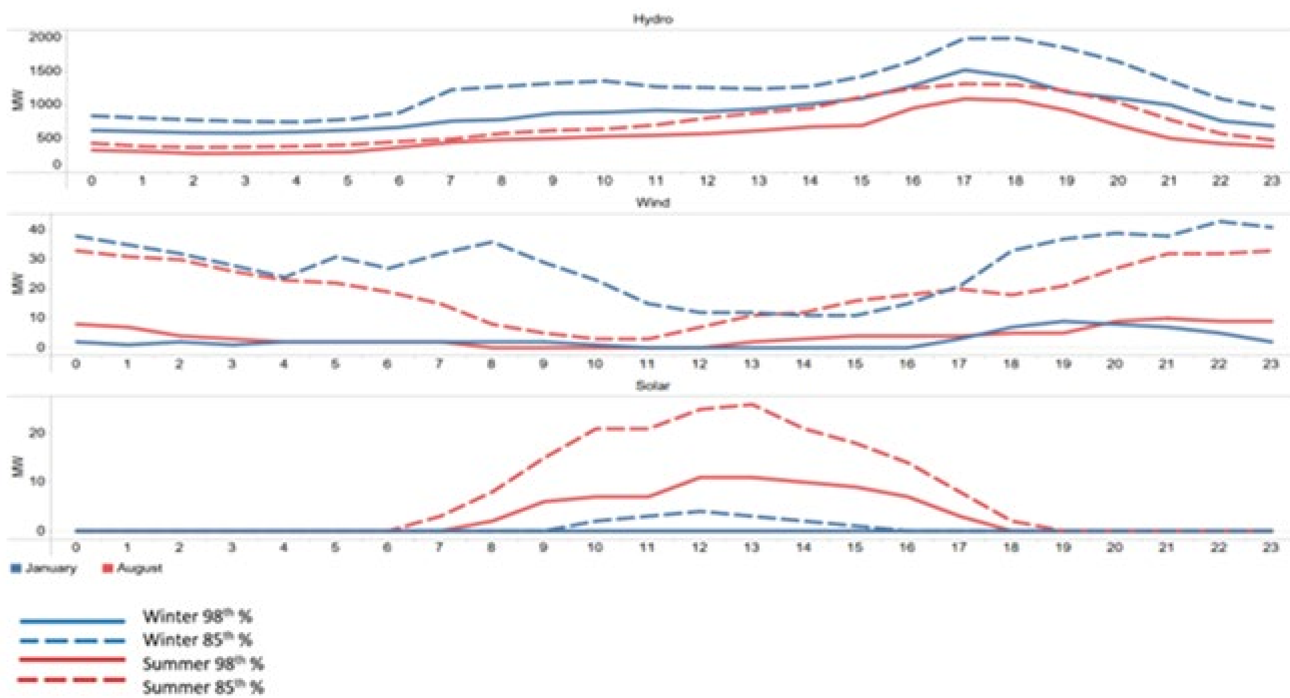
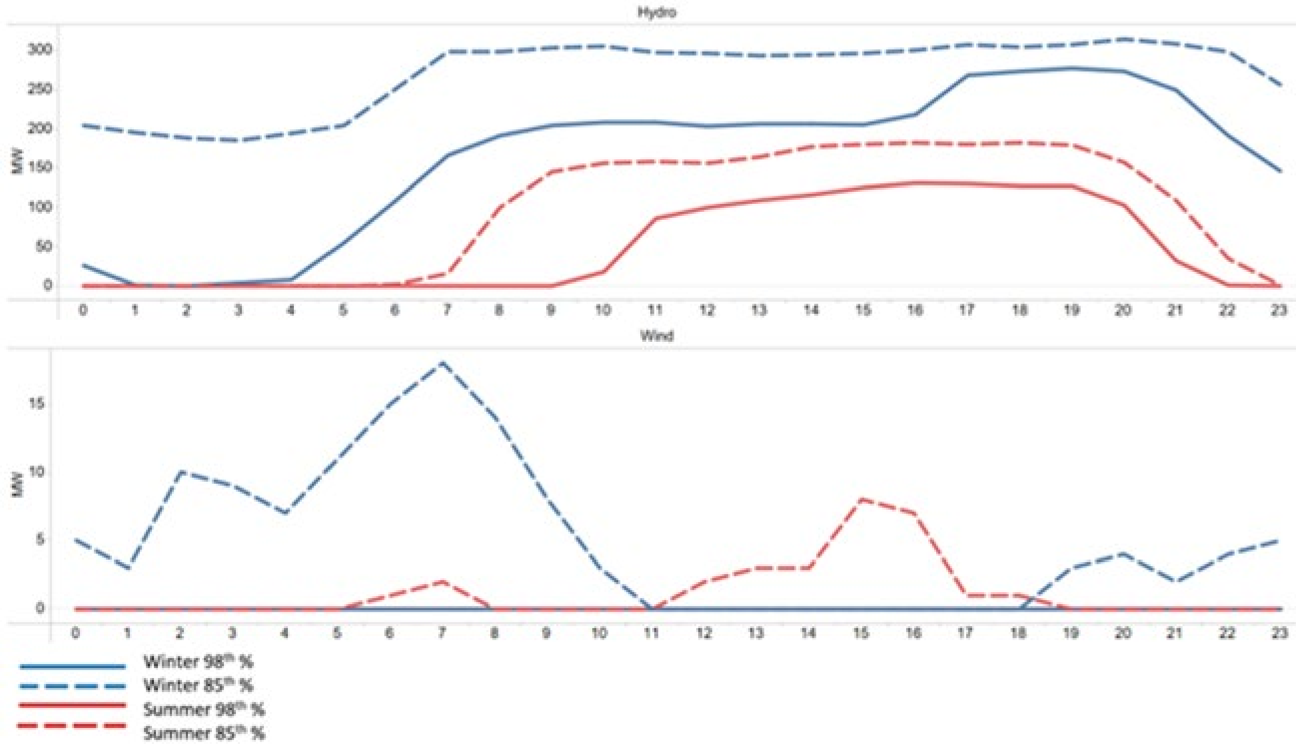


Figure 5.3| Aggregated Daily 98 and 85 Percentile Generation Profiles for the Essa Zone



6 Remedial Action Scheme (RAS)

A Remedial Action Scheme (RAS) is designed to detect predetermined system conditions and automatically take corrective actions. These actions may include, but are not limited to, adjusting or tripping generation (MW and Mvar), shedding load, or reconfiguring a portion of the transmission system by tripping circuits and or transformers to redirect the flow of power. A RAS is used to meet established planning criteria in lieu of additional transmission and/or supply resources. All RASs must be classified based on the impact to the bulk electric system (BES) and/or bulk power system (BPS) should they misoperate or fail to operate. Depending on the classification, ORTAC specifies criteria limiting the use of a RAS as follows:

- Relying on an NPCC Type I RAS for NPCC A-2 design criteria contingencies with all transmission elements in-service must be reserved only for transition periods while new transmission reinforcements are being brought into service.
- With any one element out of service (N-1), planned load curtailment or load rejection, excluding voluntary demand management, is only permissible to account for local generation outages.[17] No more than 150 MW of load may be interrupted by configuration and by planned load curtailment or load rejection, excluding voluntary demand management.
- With any two elements out of service (N-2 or N-1-1), planned load curtailment or load rejection exceeding 150 MW is only permissible to account for local generation outages.[17] No more than 600 MW of load may be interrupted by configuration and by planned load curtailment or load rejection, excluding voluntary demand management. The 600 MW load interruption limit reflects the established practice of incorporating up to three typical modern day distribution stations on a double circuit line in Ontario.

Table 6.1 provides a list of remedial action schemes that increase power transfer north on the FN and CLANE interfaces and their expected use in 2031. Note that this list only includes RASs associated with the loss of critical elements in the area of study (X503E, X504E, E510V, and E511V). Table 6.2 provides a list of RASs that increase power transfer south on the FS and CLAS interfaces and their expected use in 2031.

[17] Hydroelectric and other renewables operating at less than 100% duel to fuel availability is not considered local generation outages.

Table 6.1| List of RASs Used to Improve Transfers North

RAS	Purpose	2031 Assumption
Hanmer Reactor Tripping Scheme	To trip Hanmer TS reactors / close Hanmer TS capacitors following the loss of X503E, X504E, E510V, E511V, P502X, or D501P, to prevent post-contingency voltage criteria violations.	Need may still exist after 2031 and therefore this is still available for use.
Essa Reactor Tripping Scheme	To trip Essa TS reactors following the loss of X503E, X504E, E510V, or E511V to prevent post-contingency voltage criteria violations.	Need may still exist after 2031 and therefore this is still available for use.

Table 6.2| List of RASs Used to Improve Transfers South

RAS	Purpose	2031 Assumption
Moose River G/R	To reject hydroelectric generating units on the Mattagami and Abitibi Rivers north of Pinard TS for various contingencies, including the loss of X503E, X504E, E510V E511V, P502X or D501P to prevent post-contingency thermal overloading and transient instability.	Need may still exist after 2031 and therefore this is still available for use prior to any system enhancements.
Hanmer Reactor Tripping Scheme	To trip Hanmer TS reactors / close Hanmer TS capacitors following the loss of X503E, X504E, E510V, E511V, P502X, or D501P, to prevent post-contingency voltage criteria violations.	Need may still exist after 2031 and therefore this is still available for use.
Essa Reactor Tripping Scheme	To trip Essa TS reactors following the loss of X503E, X504E, E510V, or E511Vto prevent post-contingency voltage criteria violations.	Need may still exist after 2031 and therefore this is still available for use.

7 Study Methodology and Criteria

The IESO is required to follow various reliability standards when conducting system studies, including criteria set by the North American Electric Reliability Corporation (NERC) and the Northeast Power Coordinating Council (NPCC). These standards require bulk system planning to account for specific operating conditions, such as peak and light load, as well as a range of contingencies, to ensure the system is sufficiently reliable.

The IESO also defines its own performance criteria that must be met under the specified conditions. The Ontario Resource and Transmission Assessment Criteria (ORTAC) define the planning performance criteria for Ontario, which are more specific and generally more stringent than those required by NERC/NPCC. A full list of reference documents is listed in Section 14.

A transmission security analysis was performed to examine the capability of the transmission system to securely meet power transfer requirements for the respective system demand and supply outlooks.

7.1 Criteria

7.1.1 Thermal Loading Criteria

Based on Section 4.7.2 of ORTAC, the following thermal criteria were applied:

- With all elements in-service, equipment must not be loaded above continuous ratings.
- With one element out-of-service, equipment must not be loaded above long-term emergency (LTE) ratings.[18]
- With any two elements out-of-service, equipment loading must be within applicable short-term emergency (STE) ratings, with the ability to reduce the loading on the equipment back to within the LTE ratings within the time afforded by the STE rating.[19]

[18] Long-term emergency ratings are generally a 10-day limited time rating for transformers, and a continuous or 50 hour/year rating for transmission circuits.

[19] Short-term emergency ratings are generally 15-minute or 30-minute limited time ratings for transformers and transmission circuits.

7.1.2 Voltage Change Criteria

Based on section 4.3 of ORTAC, the minimum and maximum voltages and voltage change criteria shown in Table 7.1 were applied.

Table 7.1 | Post-Contingency Voltage Requirements

Post-Contingency Voltage Requirements	Nominal Bus Voltage (kV)	Nominal Bus Voltage (kV)	Nominal Bus Voltage (kV)
Applicable Limit	500	230	115
Post-contingency Maximum Voltage[20]	550	250	127[21]
Post-contingency Minimum Voltage	470	207	108
Post-contingency Maximum Deviation	10%	10%	10%

7.1.3 Stability Margin Criteria

Based on Section 3.3.2 of ORTAC, a 10% margin on stability were applied. In other words, the system must be shown to be stable if the most critical parameter is increased by 10%, for the following conditions:

- 10% margin on pre-contingency voltage collapse
- 10% margin on post-contingency voltage collapse
- 10% margin on transient instability

7.2 Methodology

7.2.1 Identifying Study Interfaces

For study purposes, transmission interfaces are usually defined as any circuit or group of transmission circuits connecting two sub-systems of the IESO-controlled grid.

7.2.1.1 Study Interfaces for the Northward Flow Scenarios Assessing Load Security

Flow North (FN)

The FN interface comprises the circuits connecting the Essa Zone and the Northeast Zone. This includes two 500 kV circuits (X503E and X504E) north from Essa TS and one 230 kV circuit (D5H) north into Otto Holden TS. FN transfer capability is important to reliably supply demand in the Northeast and Northwest zones, and to facilitate exports to Manitoba, Minnesota, and Quebec.

[20] Post-Contingency Voltages up to 263 kV and 133 kV are acceptable, provided there is a mechanism to reduce voltages within 30 minutes, as per IESO-H1 agreement.

[21] In Northern Ontario, individual bus voltage limits may exceed 127 kV and can be as high as 132 kV.

Claireville North (CLANE)

The CLANE interface consists of the circuits connecting the Toronto and Southwest Zones to the Essa Zone. This includes two 500 kV circuits (E510V and E511V) north from Claireville TS, two 230 kV double circuits (H82V and H83V north from Claireville TS and E8V and E9V east from Orangeville TS) and one 115 kV circuit (S2S) east into Stayner TS. CLANE transfer capability is important to reliably supply demand in the Essa, Northeast, and Northwest zones, and to facilitate exports to Manitoba, Minnesota, and Quebec.

For this portion of the assessment, it is assumed all other interfaces north and west can sufficiently meet load security criteria.

7.2.1.2 Study Interfaces for the Southward Flow Scenarios Assessing Transmission Reinforcements Effect on Congestion and Enabling New Generation

Flow South (FS)

The FS interface is defined as the opposite of the FN interface (flow south into Essa TS and south out of Otto Holden TS) and is utilized to transfer excess power from the NE and NW zones, plus imports to the load centres in the GTA.

Claireville North (CLAS)

The CLAS interface is defined as the flow into Claireville TS, rather than out on E510V, E511V, H82V, and H83V and is utilized to transfer excess power from the NE, NW, and Essa zones, plus imports to the load centres in the GTA.

7.2.2 Determining Transfer Capability

Transfer capability is defined as the maximum amount of electric power that can be transferred over the transmission network from one area to another, under specific conditions. This involves assessing the system's ability to handle power flows while maintaining reliability and security standards.

To determine the transfer capability for identified study interfaces, the IESO adopts the following methodology:

- Power transfer is incrementally increased by using the IESO’s Guidelines for Determining Transfer Capability. The point at which the power transfer being simulated is marginally meeting performance criteria for credible Planning Events and Contingency Events – in accordance with NPCC Directory #1, NERC TPL-001, and ORTAC[22] – is deemed the Transfer Capability of the Bulk Transmission Interface.
- Performance is measured by conducting steady state assessments and transient assessments. In general, steady state assessments are performed first until a power transfer is achieved that marginally meets performance requirements associated with

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[22] In contingency analysis, the studied contingencies are in accordance with Planning Events P0-P7 listed in the NERC standard TPL-001-4. For BPS elements, contingencies are in accordance with Category I and II Contingency Events listed in the NPCC Directory #1.

steady state performance (the "Steady State Result"). ORTAC requires transient performance requirements to be met with a 10% margin, so power transfer is further simulated 10% above the Steady State Result, and transient performance is assessed. If transient performance requirements are satisfied, the transfer capability is considered equal to the Steady State Result. If transient performance requirements are not met, the power transfer will be reduced until transient performance requirements are marginally met (the "Transient Result").

7.2.3 Identifying Reliability Related Needs

The Transmission Security Analysis constitutes two tests:

1. Determining the transfer capability with all elements initially in-service, with a required transfer determined from the net of extreme weather peak demand and dependable generation[23] (e.g., 98% hydroelectric) in the "sink" subsystem.[24]
2. Determining the transfer capability with an element initially out-of-service, with a required transfer determined from the net of normal weather peak demand and dependable generation (e.g., 85% hydroelectric) in the "sink" subsystem.

The transfer capabilities along with the internal dependable generation then determine Load Meeting Capability (LMC) for a given area. When the LMC is lower than the forecasted demand, a need is present.

7.2.4 Identifying Impact on Congestion

Congestion was assessed by performing an energy assessment over the course of a year (8,760 hours), where additional non-emitting generation was added to the NW and NE zones in the quantities shown in Table 7.2, while respecting the East West Tie East (EWTE) transfer limit and the FS transfer limit[25] for the specified transmission reinforcement option(s). It is assumed that the generation would be connected such that no other local transmission limitations would limit the amount of generation, including limitations to inverter-based generation (i.e., the only the limit on the FS interface would result in congestion). The quantities tested are meant to provide an indication of how the transmission reinforcements can enable a generation portfolio with various amounts of different types on new non-emitting resources.[26] Depending on how different types and quantities of generation are connected in this part of the province, the transfer limits and congestion would be subject to change.

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[23] Dependable output from other generation, such as natural gas, renewables and bioenergy, was assumed as its system capacity contribution. This is typically equal to the facility's unforced capacity (UCAP).

[24] The "sink" subsystem is the portion of the power system that the transmission interface is transferring power to.

[25] For transient stability assessments, the results depend heavily to the detailed placement and type of generation, the associated control systems, and any upstream transmission reinforcements required to connect that generation. Therefore, all new generation was assessed as negative load in the transient portion of the assessment.

[26] This test is not intended to indicate that this portfolio is the correct portfolio of generating assets to build, nor is it endorsed as the plan. Rather, it is used to compare transmission options on how effectively the enable generation in Northern Ontario.

Congestion was calculated by assessing the new energy resources shown in Table 7.2, injected for a constrained run with the FS limit unconstrained, and an unconstrained run using the following formulation:

(New energy injected UC - New energy injected C) / New energy injected UC
where: UC = Unconstrained Run and C = Constrained Run

Table 7.2|Amounts of New Generation Added (Nameplate Values MW)

Zone	Portfolio A (2035)	Portfolio B (2035)	Portfolio C (2035)	Portfolio D (2035)	Portfolio E (2035)
Northwest Wind	450	450	450	450	450
Northwest Hydroelectric	50	50	50	50	50
Northeast Wind	1,000	1,000	2,000	2,000	2,000
Northeast Solar	800	800	800	1,800	1,800
Northeast Hydroelectric	1,000	1,000	1,000	1,000	2,000
Northwest Baseload Generation	300	300	300	300	300
Northeast Baseload Generation	900	1,800	900	900	900
Total New	4,500	5,400	5,500	6,500	7,500

The following additional assumptions were used while comparing the impact of transmission reinforcements on congestion:

- Imports/Exports from Manitoba and Minnesota were set to zero.
- Existing Northwest and Northeast wind and solar profiles were applied and scaled up to reflect new nameplate generation quantities in each zone.
- For Hydro with metered data, hourly profiles of a median year were applied.
- For Hydro and thermal facilities without metered data, hourly capacity factors derived from all stations with data were applied.
- The potential forecast was applied.
- All off-contract thermal units and wind facilities units were assumed to be out of service (O/S).

8 Existing Transfer Capability and Needs

8.1 Transfer Capability for Flow North Conditions

Periods of low hydroelectric output result in power flowing north on this interface, in turn supplying the demand in Northern Ontario. Table 8.1 provides the summarized transfer capability in accordance with the methodology listed in Section 7.

Table 8.1 | FN Transfer Capability

FN Transfer Capability	Summer (MW)	Winter (MW)
2031 System ALL I/S	1,820	2,310
2031 System XxE O/S	435	520

When all transmission elements are in service, the FN interface is limited by:

- Thermal ratings on X504E[27] for the loss of X503E in the summer months; and
- Voltage collapse north of the Hanmer area for several breaker fail contingencies, resulting in the loss of one of the X503E/X504E circuits plus the loss of either the Hanmer TS autotransformer or one of the E510V/E511V circuits.

When one of X503E or X504E is out of service, the FN interface is limited by thermal ratings on D5H for the loss of the companion 500 kV circuit.

8.2 Transfer Capability for Flow South Conditions

During periods of high hydroelectric output combined with imports from neighbouring jurisdictions and/or other forms of generation in Northern Ontario, power flows south on the FS interface to help meet peak demand in Southern Ontario.

In accordance with the methodology listed in section 7, the analysis determined the transfer capabilities for the FS interface, with the results is summarized in Table 8.2.

Table 8.2 | FS Transfer Capability

FS Transfer Capability	Summer (MW)	Winter (MW)
2031 System ALL I/S	1,760	2,480

[27] Note: The Summer and Winter ratings for X504E are ~220 and 150 Amps lower than X503E.

During both the summer and winter months, FS is limited by thermal exceedances on X504E for Hanmer PL503/JL503 breaker fail contingencies. Transient stability is the current limiting phenomena; however, this is expected to change because of the decreased flows south from Timmins on P502X due to:

- New transmission (X505P and P503W)
- The potential retirement of thermal units north of Sudbury
- Additional forecasted load in the Timmins and Kirkland Lake area

The FS transfer limit is used to determine how any system changes would result in congestion. Outage conditions would result in lower transfer capability and, therefore, more congestion. However, the timing and duration of planned outages are expected to be coordinated with the availability of generation to reduce congestion. Congestion during forced outages may create deliverability challenges for future procurements, especially capacity products intended to supply peak system demand in Southern Ontario.

8.3 Needs For Flow North Conditions

Consistent with the methodology in Section 7, reliability needs were calculated and are presented below. As previously noted in Section 5, the supply mix has the potential for generation retirements as well as energy-limited generation, which varies significantly between peak and off-peak hours. For these reasons, needs were assessed for both on peak and off-peak hours, utilizing the generation profiles in Section 5.

Figure 8.1 and Figure 8.2 combine the transfer capabilities, along with the existing supply resources, and compares them to the demand forecast to illustrate the maximum load-meeting capability and needs for hours 4 and 20 in both winter and summer months, respectively.

This concluded that a need would arise, and the date and amount would depend on the following:

- The amount of non-committed industrial load growth and the speed at which these facilities connect as shown, when comparing the firm and potential load growth scenarios.
- The amount and dates of thermal generation retirements north of the FN and CLANE interfaces.

Needs are greatest during outage conditions and overnight hours, rather than peak hours, because of the generation profiles of energy-limited and intermittent resources. Table 8.3 summarizes the needs.

Table 8.3 | Needs North of the FN Interface

—	Firm Demand Scenario Need	Potential Growth Scenario Need
System ALL I/S	Starting in 2044, reaching 800 MW by 2050.	Starting in 2028, ~ 500–600 MW from 2030–2039, reaching 1,700 MW by 2050.
XxE O/S	330 MW in 2024, reaching 1,200–1,400 MW by 2031–2040 and reaching 2,477 MW by 2050.	500 MW in 2024, reaching 2,000–2,200 MW by 2031–2040 and reaching 3,300 MW by 2050.

Figure 8.1| Load-Meeting Capability North of the FN Interface for the Winter Months

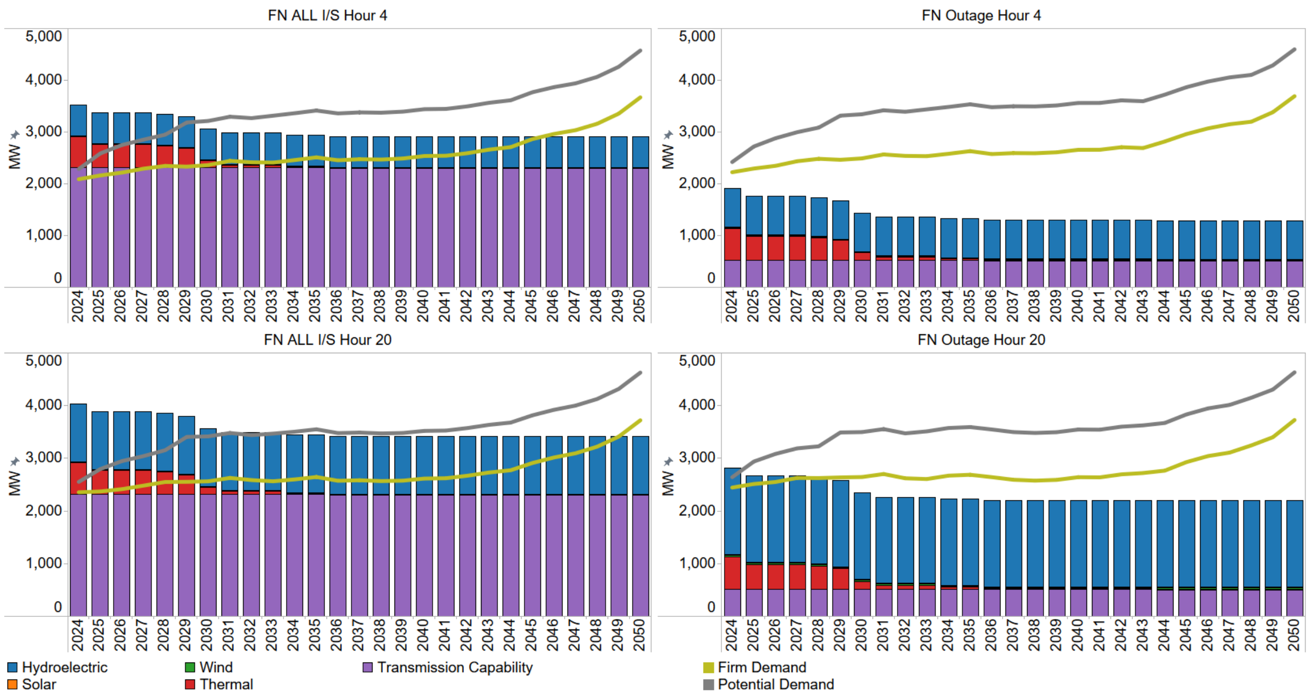
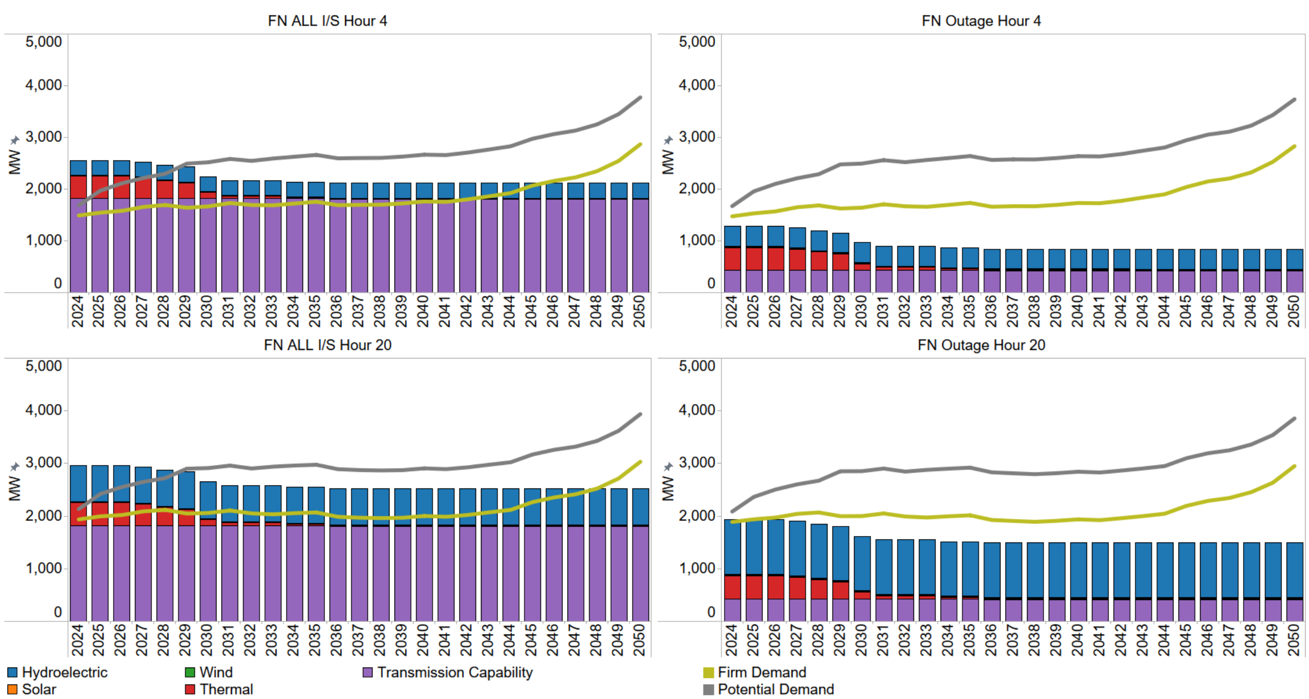
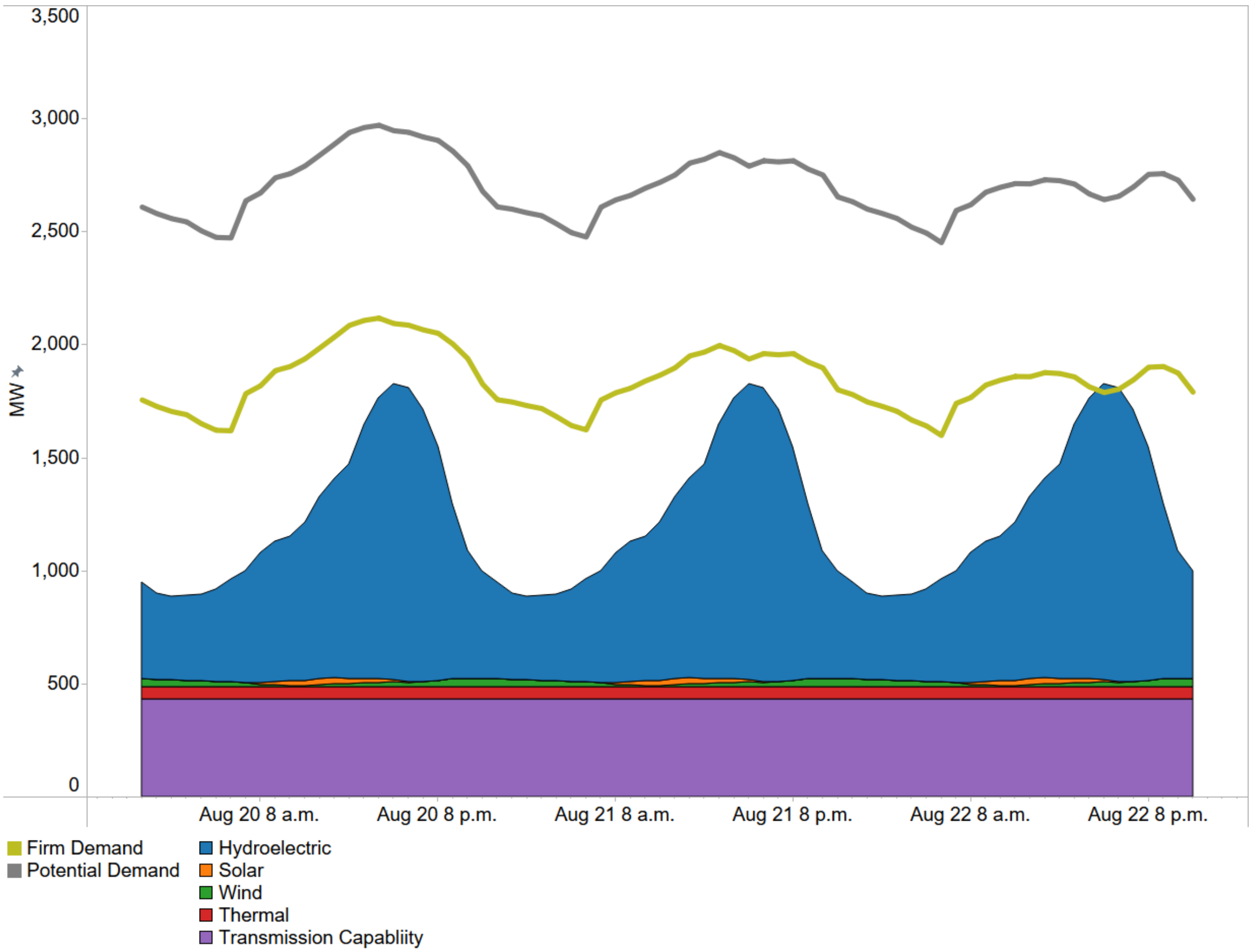


Figure 8.2| Load-Meeting Capability North of the FN Interface for the Summer Months



The large capacity gap, along with the nature of the existing energy-limited resources, creates an energy need north of the FN interface. Figure 8.3 provides an indication of the energy need, should the outage last 72 hours.

Figure 8.3| Summer 2031 Peak Demand Energy Gap (72hours)



9 Evaluation of Options

Section 8 indicated that there would be insufficient supply to the focus areas due to the forecast electricity demand growth from the industrial sector. This section develops and evaluates both Wires and Non-Wires Alternatives to find the most effective solution to supplying this load growth in the focus area. Key aspects, including technical feasibility, ability to address needs, cost-effectiveness, ability to enable generation in Northern Ontario, and implementation lead time were considered when evaluating options.

9.1 Non-Wires Alternatives (NWA)

In response to the identified bulk system needs in meeting the demand forecast in Northern Ontario, non-wires alternatives were considered with a wide range of new resource types, including storage, solar and wind, hydroelectric, thermal small modular reactor, biofuel, and hydrogen fuel cell as well as non-resource options like energy efficiency and remedial action schemes. These resources were considered alone and in combination with other resources to meet the demand forecast. The IESO's screening assessment results for various NWAs is summarized as follows:

- **Hydroelectric** –Hydroelectric development requires long lead times and additional transmission infrastructure to be located at sites with suitable geographic features. Additional transmission on the FS/CLAS interfaces would also ne needed to prevent excessive southward congestion when peaking hydro facilities are generating at high capacity. These timelines would not align with the need; therefore, this option is not a feasible one.
- **Small Modular Reactor (SMR)** – SMRs are not considered to be a viable option, given the time of need. The first commercial SMR is slated for operation circa 2029 and is still yet to be tested. Installing several additional SMRs in Northern Ontario that would be operational three years after the first commercial SMR in North America is operational at Darlington is not feasible.
- **Hydrogen Fuel Cell** – Fuel cells are not considered to be a viable alternative, as the commercial application of hydrogen fuel cells is yet to be developed.
- **Remedial Action Scheme** – The magnitude of the needs exceeds the allowable amount of load that could be rejected via a load rejection scheme. Therefore, this option was excluded from further consideration.
- **Demand Response (DR)** – Demand response products could offer a cost-effective way of managing flows by acting as a 'virtual' generator and reducing consumption when called upon. The IESO may explore leveraging existing procurement mechanisms to secure capacity from demand response to help meet short-term reliability needs brought on by outage conditions in the region.

- **Energy Efficiency (EE)** – EE serves as an important component of the Electricity Demand Side Management (eDSM) program. This program encompasses the allocation of budgets and establishment of targets for a diverse array of energy-saving initiatives beyond the scope EE alone. Incremental EE, which refers to measures that incremental to those developed to achieve provincial targets, is not considered to be a viable alternative, as the magnitude of bulk needs exceeds the capability of EE to cost-effectively meet these needs.
- **Wind, Solar and Storage Hybrid** – The requirement identified in Section 8 is evident during all hours and throughout all seasons, with the highest demand occurring overnight, as demonstrated in Figure 5.2. As a result, the combined capacity of wind, solar, and battery storage is projected to exceed 10,000 MW by 2050, reflecting the intermittent nature of wind and solar generation. Since Ontario is experiencing provincial demand growth that requires additional resources, this option was compared with the preferred transmission option described in Section 9.4.
- **Gas Generation** – The implementation of gas generation in Northern Ontario presents significant challenges, particularly in the absence of enhancements to the transmission infrastructure.
- **Biomass** – The scale of the need, combined with the frequency of the need and operational challenges (including fuel availability and long lead times), results in biomass not being regarded as a viable option at this time.

9.2 Wires Options

To address the identified reliability issues, various wires options were developed to improve the FN interface transfer capability. The reinforcements in Table 9.1 were assessed.

Table 9.1 | Transmission Reinforcements Considered

Reinforcement	Description
A	• Reconductor D5H with 1,192 kcmil 54/19 Aluminum Conductor Steel Reinforced (ACSR)*
B	• Add an additional single 230 kV circuit in parallel to D5H with 1,192 kcmil 54/19 ACSR,* keep D5H as is • Add an additional single 230 kV circuit in parallel to H23S/H24S with 1,192 kcmil 54/19 ACSR* • Reconductor M6E/M7E with 1,192 kcmil 54/19 ACSR*
C	• Build an uncompensated[28] 500 kV circuit between Hanmer TS and Essa TS with ratings as good or better than X503E

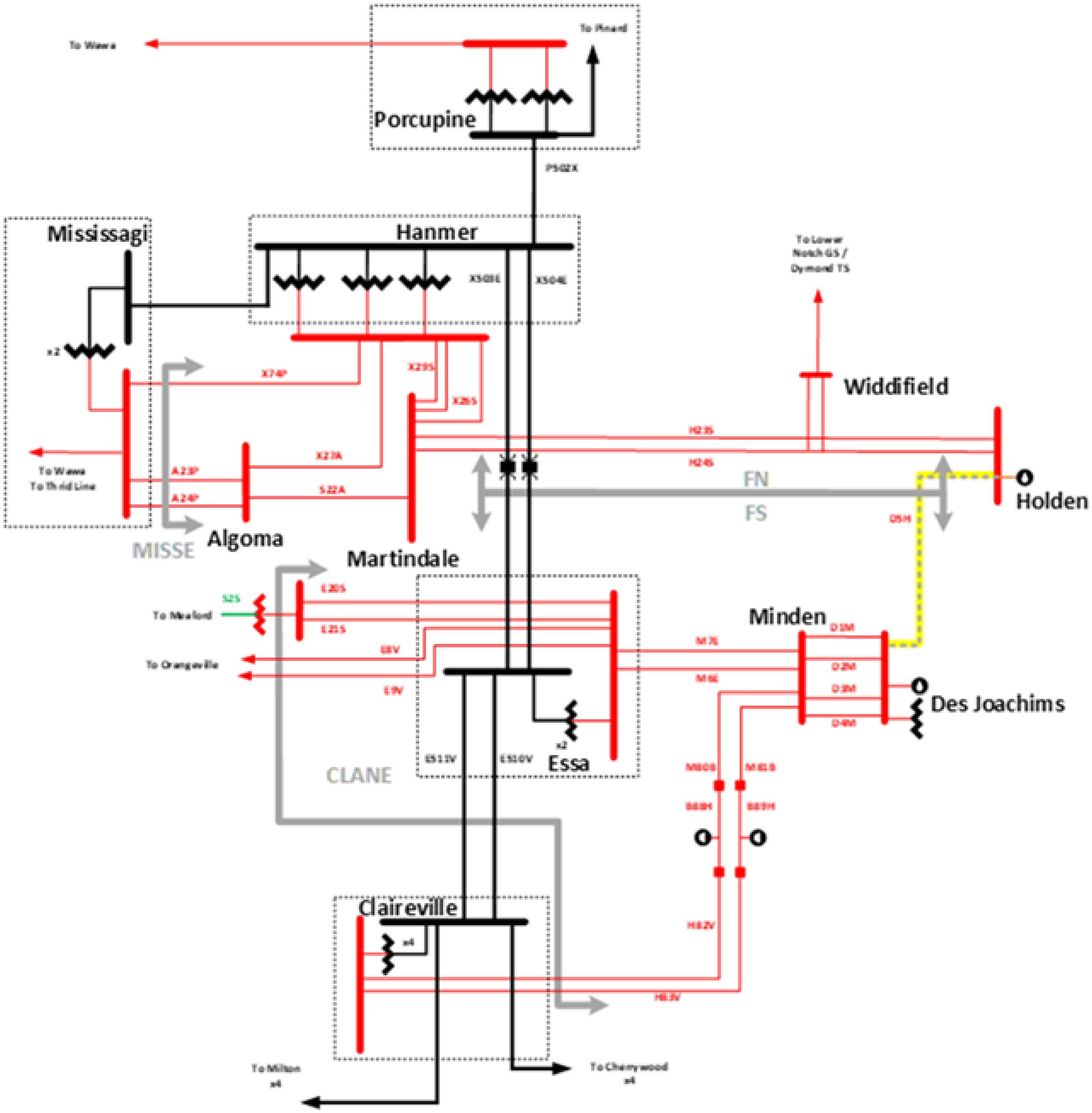
*Or equivalent ampacity Aluminum Conductor Composite Core ACCC or Aluminum Conductor Steel Supported (ACSS) conductor.

[28] See Appendix B for an explanation of the layout for the uncompensated circuit.

9.2.1 Option A

Option A consists of reconductoring the 91 km 230 kV circuit D5H with a 1,192 kcmil 54/19 ACSR conductor (or equivalent), as shown in Figure 9.1.

Figure 9.1 | Single Line Diagram of Option A



9.2.1.1 FN Transfer Capability – XxE Outage

Reconductoring D5H minimally increases the FN interface transfer capability for the planning event of an outage to either XxE, plus the loss of the companion. The issue is then transferred to the adjacent transmission elements either upstream or downstream of D5H, as shown in Table 9.2. Any option involving reconductoring D5H would require additional upgrades, such as, but not limited to, reconductoring M6E and M7E, as well as H23S and H24S, to achieve a meaningful transfer capability increase on the FN interface. This option would not materially change the impedance on the FN/FS interface and, therefore, would not change the distribution factors, and would not result in any improvements to the All I/S FN and FS transfer capabilities. Furthermore, the FN transfer capability during an XxE outage would ultimately be limited by voltage-related phenomena at 750 MW (incremental 315 MW), well short of the 1,300 MW need by 2031 for the Firm Demand Scenario. For all these reasons, this option is deemed technically infeasible and was not considered for further evaluation.

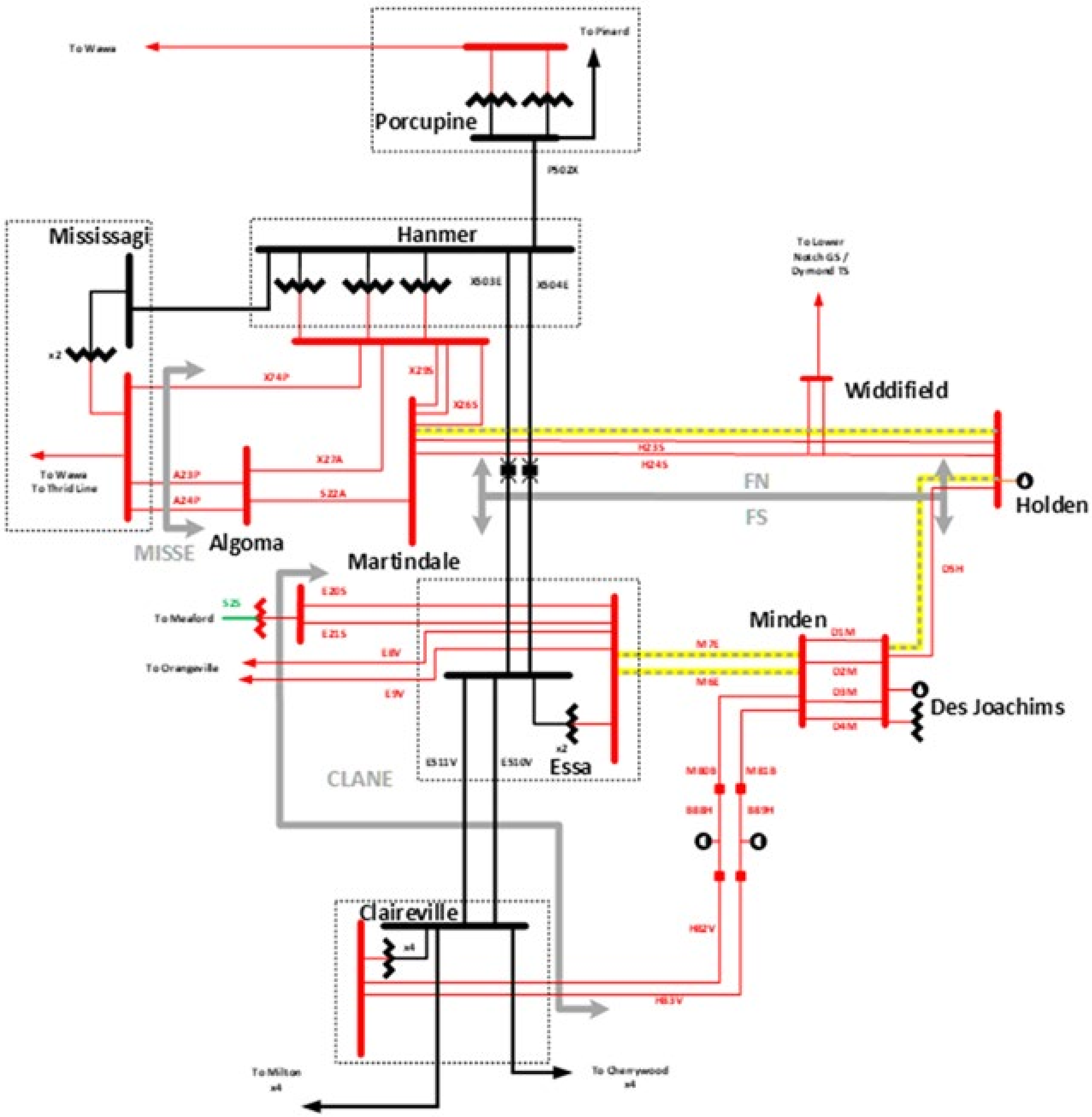
Table 9.2 | Option A Results for an XxE O/S

Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
435	490	55	Thermal exceedance on M6E/M7E for loss of companion XxE

9.2.2 Option B

Option B consists of a new 91 km 230 kV 1,192 kcmil 54/19 ACSR conductor (or equivalent) circuit 'D99H' between Otto Holden TS and Des Joachims TS, and a new 175km 230 kV 1192 kcmil 54/19 ACSR conductor (or equivalent) circuit 'H98S' between Otto Holden TS and Martindale TS, as well as reconductoring the entirety of M6E and M7E (120km each), as shown in Figure 9.2.

Figure 9.2| Single Line Diagram of Option B



9.2.2.1 FN Transfer Capability – XxE Outage

Adding new circuits in parallel to D5H and H23S/H24S offers minimal improvement to the FN interface transfer capability during an outage, to either XxE. A total of 355 MW of incremental improvement is achieved, at which point post-contingency thermal exceedances occur on sections of H23S and H24S due to the low thermal rating on those circuits. Table 9.3 provides incremental FN transfer capability in the summer months. Even with additional reconductoring of H23S, H24S and D5H, the FN transfer capability during an XxE outage would then be constrained by voltage-related instability, at 990 MW (incremental 555 MW), well short of the 1,300 MW need by 2031 for the Firm Demand Scenario.

This option results in a negligible overall change in impedance on the FN/FS interface. This, in turn, yields only marginal improvements in the transfer capability of both FN and FS when all elements are in-service, therefore restricting demand growth and the enablement of resources.

For all of these reasons, this option is deemed technically infeasible and was not considered for further evaluation.

Table 9.3 | Option B Summer Results for an XxE O/S

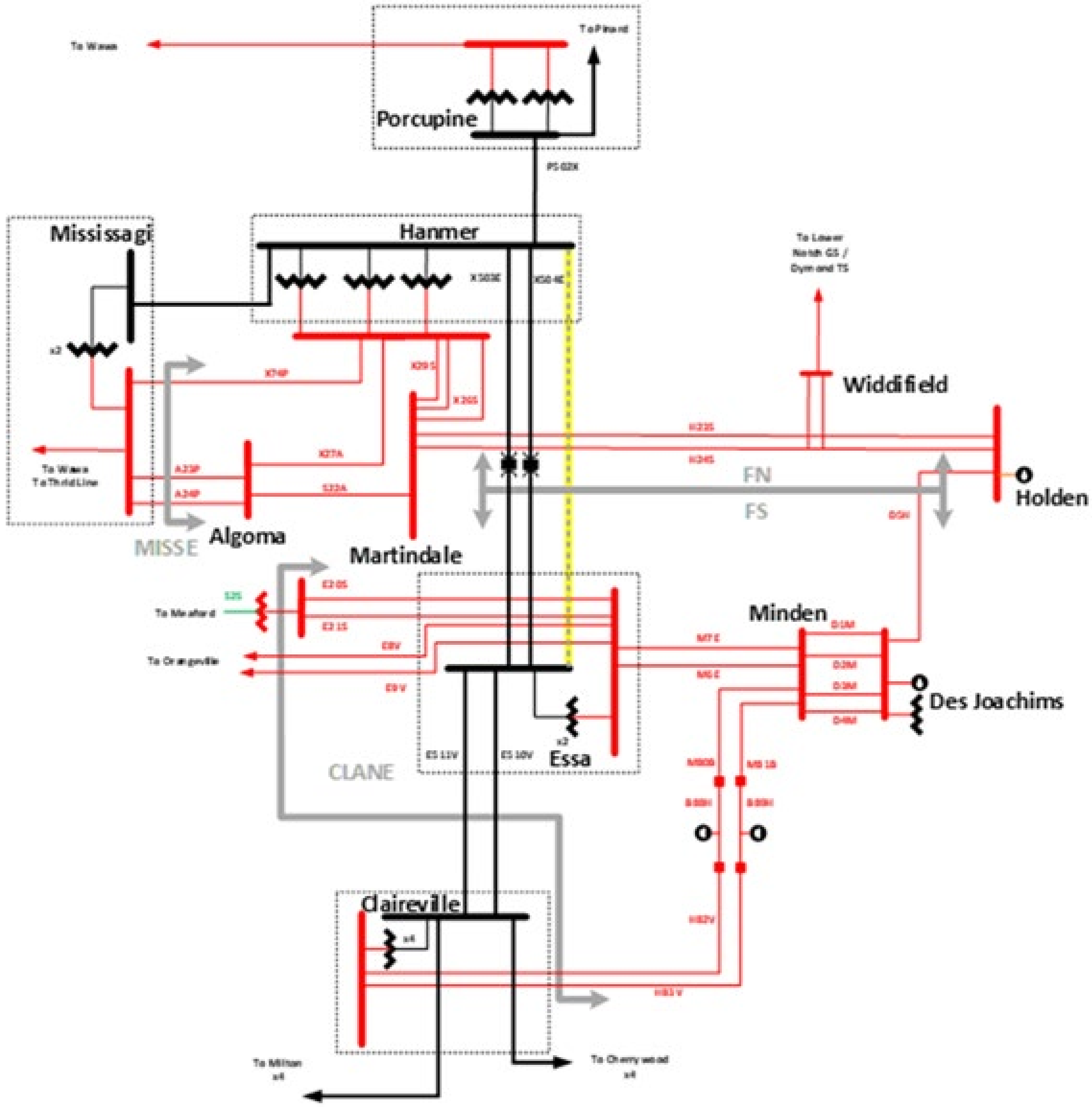
Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
435	790	355	Thermal exceedance on H23S/H24S for loss of companion XxE

9.2.3 Option C

This option consists of a new 270 km 500 kV circuit 'X599E' between Hanmer TS and Essa TS, as shown in Figure 9.3. The existing circuits (X503E and X504E) incorporate series compensation to increase the existing All I/S transfer capability by lowering the impedance on each of the existing circuits by 50%. The series compensation devices are designed in such a way that they can be bypassed or left in service. The effect of series compensating these circuits results in an inability to then bifurcate the circuits should the need to arise to connect demand or generation facilities along the route. Therefore, two options were assessed to show the possible range of transfer capability:

- All three circuits with 50% series compensation
- Series compensation removed from X503E and X504E (bypassed)

Figure 9.3| Single Line Diagram of Option C



9.2.3.1 FN Transfer Capability – XxE Outage

During this outage, there are no other limitations on the CLANE interface south of Hanmer TS. Transfer capabilities for the summer months shown in Table 9.4 where the uncompensated option results in a higher summer transfer capability because of the XxE path having higher impedance and therefore more power flows on the 230kV circuit D5H, better utilizing all circuits and therefore resulting in higher transfers. Table 9.5 provides the winter transfer capabilities which are limited by voltage collapse phenomena in the Sudbury area for both the compensated and uncompensated case.

Table 9.4 | Option C Summer FN Results for an XxE O/S

Series Compensated	Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	430	1,795	1,365	Thermal exceedance on new 500 kV Hanmer TS x Essa TS circuit for loss of companion XxE
No	430	1,930	1,500	Thermal exceedance on new 500 kV Hanmer TS x Essa TS circuit for loss of companion XxE

Table 9.5 | Option C Winter FN Results for an XxE O/S

Series Compensated	Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	520	2,500	1,980	Voltage Collapse in the Sudbury area for breaker fail contingencies which removes one XxE and ExV
No	520	2,020	1,500	Voltage Collapse in the Sudbury area for breaker fail contingencies which removes one XxE and autotransformer

9.2.3.2 FN Transfer Capability – All Elements I/S

Table 9.6 and Table 9.7 list the maximum transfer capabilities possible for the FN interface if system reinforcements were made within the Essa Zone to allow the CLANE interface to become non-limiting. Without those system reinforcements, the CLANE interface becomes limiting following this upgrade, as indicated below. Therefore, the increased All I/S transfer capability on the FN interface would not be realized as it would be limited to ~400 MW for both summer and winter. This limitation of the CLANE interface will be noted here, in Section 11.2 and further assessed via the South Central Bulk Study.

Table 9.6 | Option C Summer FN Results for All Element I/S

Series Compensated	Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	1,820	3,580*	1,760	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency removing one XxE and ExV or JL503/PL503 Breaker Fail, however CLANE limiting.*
No	1,820	3,050*	1,230	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency removing one XxE and ExV or JL503/PL503 Breaker Fail, however CLANE limiting.*

*CLANE becomes limiting and would restrict FN to 2270 MW due to thermal exceedances on E510V/E511V for the loss of the companion if no additional system enhancements (either generation or transmission) were added between Claireville TS and Essa TS.

Table 9.7 | Option C Winter FN Results for All Element I/S

Series Compensated	Existing FN Limit (MW)	New FN Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	2310	3620*	1310	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency removing one XxE and ExV or JL503/PL503 Breaker Fail, however CLANE limiting.*
No	2310	2800**	490	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency removing one XxE and ExV or JL503/PL503 Breaker Fail, however CLANE limiting.**

*CLANE becomes limiting and would restrict FN to 2,910 MW due to thermal exceedances on E510V/E511V, for the loss of the companion if no additional system enhancements (either generation or transmission) were added between Claireville TS and Essa TS.

**CLANE becomes limiting and would restrict FN to 2,700 MW due to a voltage collapse in the Sudbury area, for the loss of an XxE and ExV circuit due to a breaker fail contingency if no additional system enhancements (either generation or transmission) were added between Claireville TS and Essa TS.

9.2.3.3 FS Transfer Capability – All Elements I/S

The proposed transmission reinforcements result in increases to the all transmission elements I/S FS (Table 9.8 and Table 9.9). For the case of the series compensated option during summer months, the limitation exists as a result of exceedances on the Essa TS x Claireville TS circuits.

Table 9.8 | Option C Summer FS Results for All Element I/S

Series Compensated	Existing FS Limit (MW)	New FS Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	1,760	2,985*	1,225	Thermal exceedance on ExV for loss of companion
No	1,760	2,760	1,000	Voltage Collapse in the Sudbury area for a JL503/PL503 Breaker Fail

*If thermal issues on the CLAS interface are addressed, FS can be as high as 3,380 MW.

Table 9.9 | Option C Winter FS Results for All Element I/S

Series Compensa ted	Existing FS Limit (MW)	New FS Limit (MW)	Incremental Capability (MW)	Limiting Phenomena
Yes	2,480	3,500	1,020	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency which removes one XxE and ExV or JL503/PL503 Breaker Fail
No	2,480	2,800	320	Voltage Collapse in the Sudbury area for an Essa TS breaker fail contingency which removes one XxE and ExV or JL503/PL503 Breaker Fail

The addition of a third uncompensated circuit between Hanmer TS and Essa TS increases the (LMC), as shown in Figure 9.4 and Figure 9.5, such that:

- The firm demand in Northern Ontario can be met for all hours up until 2044, when only the overnight hours result in a need in the Winter months during an outage.
- A need still remains in the overnight winter hours, starting in 2029, for the Potential Growth Scenario demand. However, this need can be deferred to 2040 by acquiring an additional 400 MW of capacity and by further investigating the shifting of some peaking hydro production, to be used at night during outage condition as shown in Figure 9.6.

The operation of peaking hydroelectric resources could be adjusted through market mechanisms and/or storage-based resources. Section 9.3 provides additional mechanisms to further increase the LMC in a staged manner.

Figure 9.4| Load Meeting Capability North of FN for the Winter Months With A Third Uncompensated 500 kV Circuit

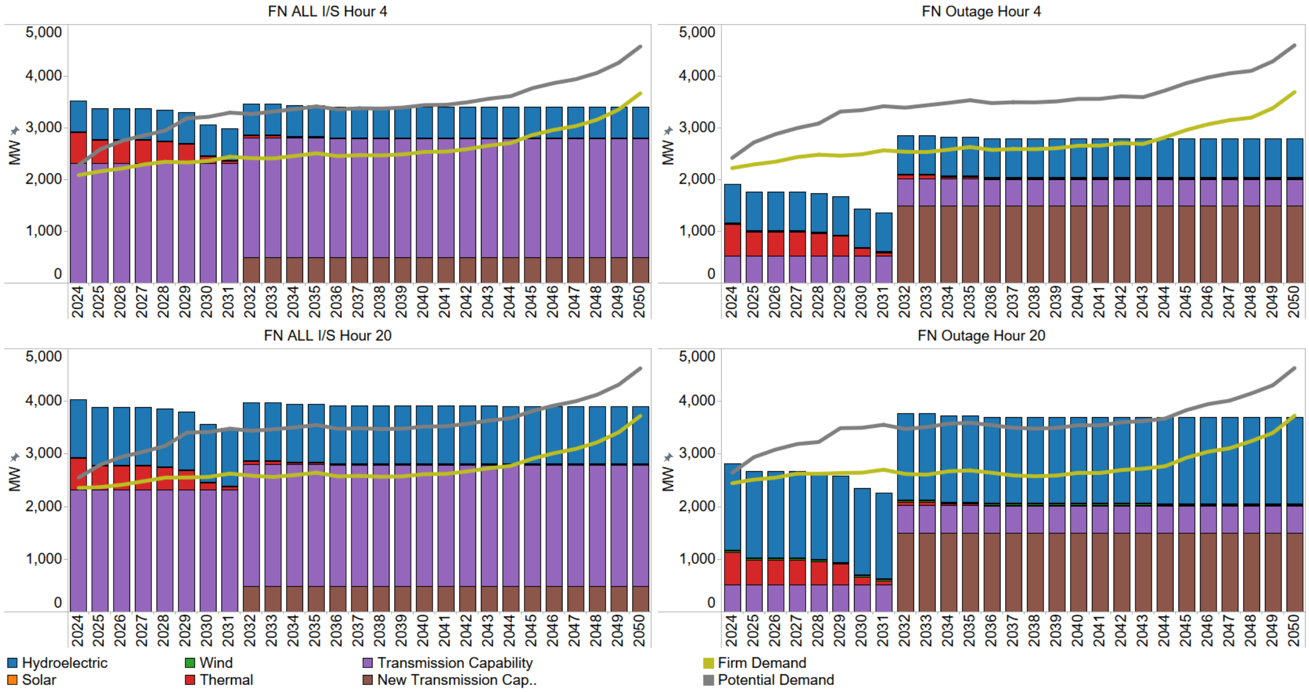
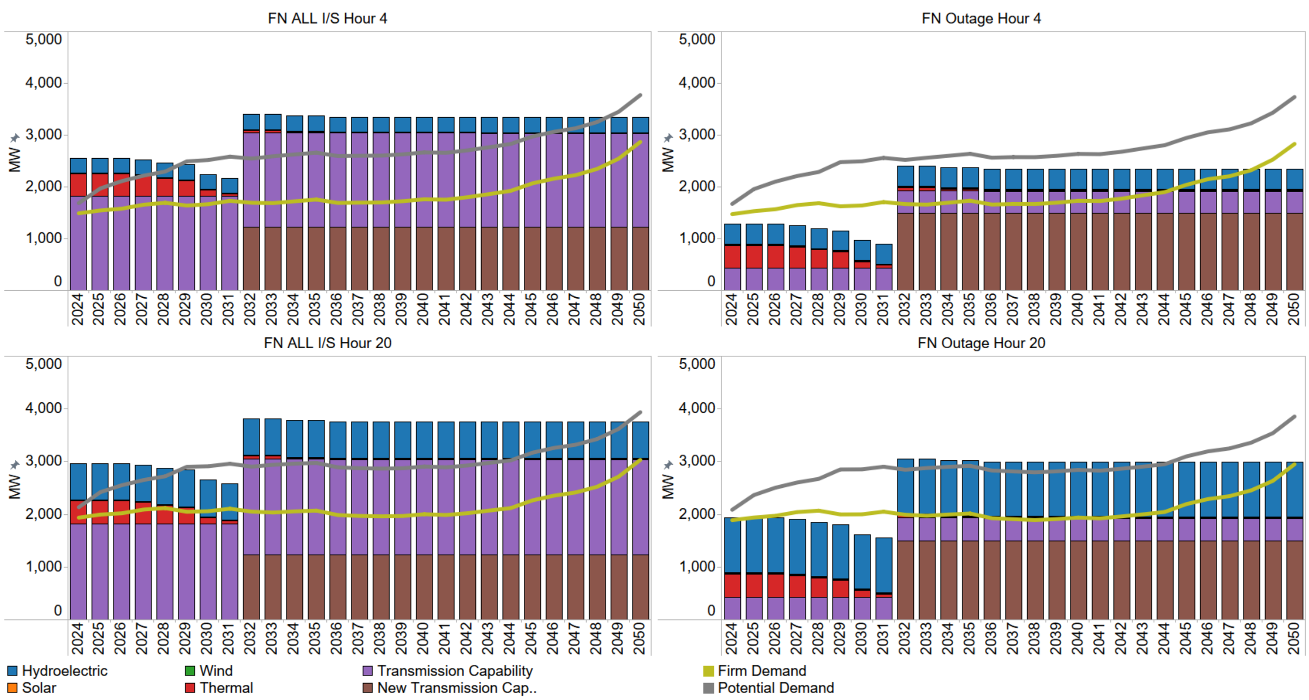


Figure 9.5| Load Meeting Capability North of FN for the Summer Months With A Third Uncompensated 500 kV Circuit



9.3 Economic Assessment and Comparison of NWA and Wires Option

Following the initial screening out of certain NWAs, the IESO developed detailed scenarios for three NWA options:

- Solar + Wind + BESS
- Wind + BESS
- Solar + BESS

Table 9.10 outlines the quantities that must be installed by the year 2032 to meet the firm forecast. It is important to note that all options will require additional resources in the coming years. In every scenario analyzed, the total resource needs significantly exceed the inverter-based resources currently available in Northern Ontario. This is due to challenges related to low fault levels and sub-synchronous control interactions, as outlined in the IESO LT2 guidance document.[29]

Additionally, substantial upgrades to the transmission infrastructure in Northern Ontario will be necessary. This includes at least one additional circuit connecting Northern and Southern Ontario, to accommodate increased hydroelectric output alongside these new resources.

As a result, the Net Present Value (NPV) would be higher than the costs shown in Table 9.11, as these figures do not take into account these essential factors.

In this analysis, the preferred transmission option is considered to provide $0 in system benefits. However, in reality, due to the increased southward transfer limits, there would be significant system benefits. This improvement would allow additional energy and capacity resources located in Northern Ontario to better support provincial resource adequacy needs.

Table 9.10 | Wind/Solar/BESS Required Amounts by 2032

Option	10h Battery (MW)	Solar (MW)	Wind (MW)
1	2,840	4,180	468
2	4,490	-	1,342
3	6,610	5,564	-

Note: None of the above Options (1, 2 and 3) meet adequacy targets and each would therefore require additional resources.

Table 9.11 | Comparison of Preferred Wires option and Non-Wires Option

Option	Cost $B	Benefit $B	Net Cost $B
New 500 kV transmission line*	1.3–1.5	0	1.3
Wind/Solar/Storage option 1	35.3	24.6	8.5

*Series Compensation would require an additional $75M.

[29] https://www.ieso.ca/-/media/Files/IESO/Document-Library/long-term-rfp/LT2-e-Guidance-2020515.pdf

9.4 Staged Approach to Enable Future Economic Development

The construction of a third 500 kV uncompensated circuit from Hanmer TS to Essa TS (and operating all three 500 kV circuits uncompensated) can be seen as a no-regrets action, as there are at least five separate options that build upon this option to further support economic growth in Northern Ontario.[30] The subsections below provide an overview of the potential additional options, as well as any other qualitative benefits. Table 9.10 Table 9.12 provide a comparison of the transfer capability improvement. Table 9.13 Table 9.14 provide a comparison of capacity needs for the higher potential demand forecast for the various options.

9.4.1 Install Additional Generation North of the FN Interface

Siting new supply resources in Northern Ontario, in particular resources that are not energy limited, would increase the LMCs and 'push back' on all interfaces like the FN and CLANE interfaces. Siting the generation at the 'last mile' can also push back on other interfaces in Northern Ontario, such as, but not limited to EWTW, MISSW, etc.

This concept in Figure 9.6, where siting resources west of Lakehead TS would 'push back' on all north and westward flows on the transmission highlighted in purple, and siting resources near Hanmer TS would only 'push back' on all northward flows on transmission highlighted in pink.

Figure 9.6| Example of Last Mile Approach

[30] Depending on future needs, some options can be combined.

Several challenges would need to be overcome with respect to siting generation, depending on the type of resource, including but not limited to:

- Additional local transmission needed to connect the generation
- Land use
- Timelines
- Avoidance of other phenomena, such as transient stability, sub-synchronous resonance, and sub-synchronous control interaction

It should be noted that the 2025 APO anticipated both an increasing energy need and a capacity need arising in the years leading up to 2050. Therefore, the location of this generation could meet multiple needs. Section 10 provides additional details on the emerging opportunities for generation in Northern Ontario.

The amount the LMC would increase would depend on the amount of dependable generation installed.

9.4.2 Explore the use of Demand Response for Outage Only Conditions

Demand response products could offer a cost-effective way of managing flows by acting as a 'virtual' generator and reducing consumption when called upon. The IESO may explore leveraging existing procurement mechanisms to secure capacity from demand response to help meet short-term reliability needs brought on by outage conditions in the region. Series Compensate the New Circuit

Adding series compensation to the third circuit, such that all three circuits are compensated, would result in a lower impedance path between Hanmer TS and Essa TS, thus reducing voltage drops and raising the transfer capability. As noted in Section 9.2.4, the needs on the CLANE interface would need be addressed to achieve the full benefit of this additional option.

As noted, this option does not increase summer transfer capability under N-1-1 criteria, since the limitation is thermal in nature. In fact, it can even result in a decline. Therefore, under certain outage conditions in the summer, it may be beneficial to bypass the series compensation devices.

9.4.3 Construct Underlying 230 kV Path

The existing 500 kV circuits X503E and X504E run in parallel to the 230 kV circuits E26 and E27 from Essa TS to Parry Sound TS. Completing the underlying 230 kV path would result in higher transfers in both the north and south directions, as this would result in a lower impedance path between Hanmer TS and Essa TS and mitigate the limiting phenomena of voltage collapse identified in Section 9.2.4. Completing this path would require constructing:

- A double 230 kV circuit between Hanmer TS and Henvy WF ~95km
- A single 230 kV circuit between Parry Sound and Henvy WF ~85km and conversion of the ~85km 230 kV circuit between Holmur CSS and Henvy WF to a network circuit
- A full 230 kV switching station at Parry Sound TS

As noted in Section 9.2.4, the needs on the CLANE interface would have be addressed to achieve the full benefit of this additional option.

The following additional benefits would be realized:

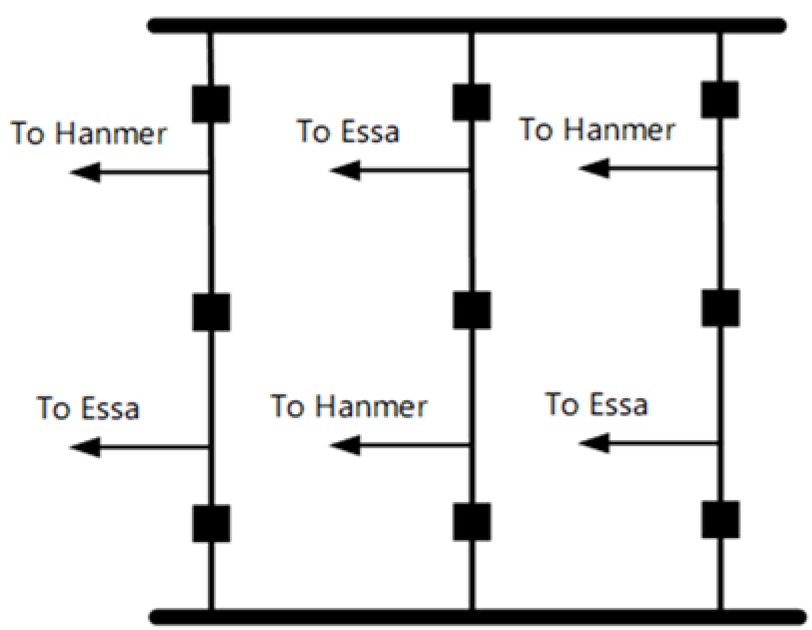
- Add an additional supply point increasing resiliency to the pocket of load in the Waubashene and Parry Sound areas. This in turn would aid in restoration times for the loss of E26 and E27.
- Add an additional 230 kV connection point east of Georgian Bay to connect renewable generation.
- Additional supply into the Sudbury 230 kV area as any power flowing on the 230 kV circuits would not need to go onto the existing auto transformers at Hanmer TS.
- Additional supply into the Essa 230 kV area as any power flowing on the 230 kV circuits would not need to go onto the existing auto transformers at Essa TS.

9.4.4 Construct 500 kV Switching Stations at Nobel SS

A station layout such as that shown in Figure 9.7 would result in a worst-case N-1-1 post-contingency topology consisting of three parallel ~150 km 500 kV circuits between Essa TS and Nobel SS, connected in series with a single ~140 km 500 kV circuit between Nobel SS and Hanmer TS. This contrasts with the alternative of a single 290 km circuit directly between Essa TS and Hanmer TS. This would result in the overall impedance being reduced by ~33%. However, it should be noted that this option would not be operable with series compensation on the 500 kV circuits and therefore would require bypassing the existing series compensation.

As noted in Section 9.2.4, the needs on the CLANE interface would need be addressed to achieve the full benefit of this additional option.

Figure 9.7| Potential Station Layout for Nobel TS



A switching station at Nobel SS also provides the option of installing an autotransformer at Nobel SS, providing the following additional benefits:

- Add an additional supply point increasing resiliency to the pocket of load in the Waubashene and Parry Sound areas. This in turn would aid in restoration times for the loss of E26 and E27.
- Add an additional 230 kV connection point east of Georgian Bay to connect renewable generation.
- Add a third autotransformer supplying the Essa 230kV area via E26 and E27.

9.4.5 Construct a Fourth 500 kV Circuit Between Hanmer TS and Essa TS

The construction of a fourth uncompensated circuit between Hanmer TS and Essa TS would allow for higher transfers in both the north and south directions, as this would result in a lower impedance path between Hanmer TS and Essa TS and mitigate the limiting phenomena of voltage collapse identified in Section 9.2.4. Adding series compensation to this circuit would provide improvements similar to those seen on the third circuit when comparing the compensated and uncompensated cases.

As noted in Section 9.2.4, the needs on the CLANE interface would need be addressed to achieve the full benefit of this additional option.

9.4.6 Comparison of Incremental Options

As noted above, additional generation or long-term demand response north of the FN Interface would not improve the FN transfer limits but would reduce the magnitude and occurrence of FN and hence is not shown in Table 9.10 through Table 9.12.

Table 9.12 | Comparison of New FN Transfer Capabilities – Summer Results

Outage	Third 500 kV Circuit (MW)	Series Compensate all Circuits (MW)	Complete 230 kV Path (MW)*	Switching Station at Nobel SS (MW)†	Fourth 500 kV Uncompensated Circuit (MW)
All Element I/S	3,050	3,580	3,575	3,270	4,160
XxE	1,930	1,805	2,280	1,930	3,050

*FN definition changed to include flow north on circuits into Hanmer 230 kV.

†Outage is Nobel SS x Hanmer TS as a result of new switching station,

Table 9.13 | Comparison of New FN Transfer Capabilities – Winter Results

Outage	Third 500 kV Circuit (MW)	Series Compensate all Circuits (MW)	Complete 230 kV Path (MW)*	Switching Station at Nobel SS (MW) †	Fourth 500 kV Uncompensated Circuit (MW)
All Element I/S	2,800	3,620	3,319	3,090	4,050
XxE	2,020	2,500	2,353	2,180	2,800

*FN definition changed to include flow north on circuits into the Hanmer 230 kV bus.

†Outage is Nobel SS x Hanmer TS, as a result of new switching station.

Table 9.14 | Comparison of New FS Transfer Capabilities – All I/S

Season	Third 500 kV Circuit (MW)	Series Compensate all Circuits (MW)	Complete 230 kV Path (MW)*	Switching Station at Nobel SS (MW)	Fourth 500 kV Uncompensated Circuit (MW)
Summer	2,760	3,380	3,255	3,070	4,000
Winter	2,800	3,500	3,230	3,175	4,430

*FS definition changed to include flow south on circuits out of the Hanmer 230 kV bus

Table 9.15 | Winter Projected Capacity Needs for the Potential Forecast for Different Options

Year	Existing System	3 Circuits Uncompensated	3 Circuits Series Compensated	4 Circuits Uncompensated	3 Circuits Uncompensated + Shifted Hydro	3 Circuits Series Compensated + Shifted Hydro	3 Circuits Compensated + 700MW of Dependable Generation and/or Demand Response	3 Circuits Compensated + 700MW of Dependable Generation and/or Demand Response + Hydro Shifting
2024	515	515	515	515	229	229	0	0
2025	966	966	966	966	674	674	266	0
2026	1,126	1,126	1,126	1,126	819	819	426	119
2027	1,246	1,246	1,246	1,246	924	924	546	224
2028	1,367	1,367	1,367	1,367	1,029	1,029	667	329
2029	1,652	1,652	1,652	1,652	1,315	1,315	952	615
2030	1,919	1,919	1,919	1,919	1,583	1,583	1,219	883
2031	2,075	2,075	2,075	2,075	1,741	1,741	1,375	1,041
2032	2,046	546	66	0	211	0	0	0
2033	2,092	592	112	0	254	0	0	0
2034	2,177	677	197	0	338	0	0	0
2035	2,235	735	255	0	400	0	0	0
2036	2,208	708	228	0	371	0	0	0
2037	2,227	727	247	0	387	0	0	0
2038	2,219	719	239	0	377	0	0	0
2039	2,234	734	254	0	384	0	0	0
2040	2,284	784	304	4	434	0	0	0
2041	2,295	795	315	15	457	0	0	0
2042	2,345	845	365	65	508	28	0	0
2043	2,339	839	359	59	522	42	0	0
2044	2,461	961	481	181	620	140	0	0
2045	2,604	1,104	624	324	759	279	0	0
2046	2,717	1,217	737	437	885	405	37	0
2047	2,800	1,300	820	520	973	493	120	0
2048	2,857	1,357	877	577	1,044	564	177	0
2049	3,064	1,564	1,084	784	1,255	775	384	75
2050	3,401	1,901	1,421	1,121	1,599	1,119	721	419

Table 9.16 | Sumer Projected Capacity Needs for the Potential Forecast for Different Options

Year	Existing System	3 Circuits Uncompensated	3 Circuits Series Compensated	4 Circuits Uncompensated	3 Circuits Uncompensated + Shifted Hydro	3 Circuits Series Compensated + Shifted Hydro	3 Circuits Compensated + 700MW of Dependable Generation and/or Demand Response	3 Circuits Compensated + 700MW of Dependable Generation and/or Demand Response + Hydro Shifting
2024	487	487	487	487	564	564	0	0
2025	745	745	745	745	789	789	45	89
2026	893	893	893	893	928	928	193	228
2027	1,034	1,034	1,034	1,034	1,055	1,055	334	355
2028	1,166	1,166	1,166	1,166	1,173	1,173	466	473
2029	1,407	1,407	1,407	1,407	1,395	1,395	707	695
2030	1,615	1,615	1,615	1,615	1,590	1,590	915	890
2031	1,752	1,752	1,752	1,752	1,711	1,711	1,052	1,011
2032	1,711	211	211	0	163	163	0	0
2033	1,759	259	259	0	188	188	0	0
2034	1,828	328	328	0	239	239	0	0
2035	1,870	370	370	0	258	258	0	0
2036	1,816	316	316	0	194	194	0	0
2037	1,822	322	322	0	195	195	0	0
2038	1,826	326	326	0	179	179	0	0
2039	1,848	348	348	0	176	176	0	0
2040	1,891	391	391	0	204	204	0	0
2041	1,876	376	376	0	240	240	0	0
2042	1,926	426	426	0	271	271	0	0
2043	1,993	493	493	0	285	285	0	0
2044	2,059	559	559	0	337	337	0	0
2045	2,210	710	710	0	459	459	10	0
2046	2,313	813	813	0	562	562	113	0
2047	2,373	873	873	0	621	621	173	0
2048	2,494	994	994	0	737	737	294	37
2049	2,716	1,216	1,216	96	965	965	516	265
2050	3,045	1,545	1,545	425	1,296	1,296	845	596

10 Emerging Generation Opportunities

Over the past decade, the IESO has recommended nearly 2,000 km of bulk transmission upgrades west of Sudbury. This transmission, along with a third 500 kV circuit between Sudbury and Barrie, presents an opportunity to locate a diverse portfolio, including new baseload generation west of Sudbury, without the need for additional bulk transmission upgrades. The ability to site generation west of Sudbury will:

- Allow further economic development of large industrial type loads in Northern Ontario, while mitigating risks associated with a need for additional long lead time bulk transmission.
- Help meet the growing provincial capacity and energy needs presented in the 2025 APO, while alleviating key interfaces east and west of the GTA, mitigating potential further bulk transmission needs in Southern Ontario:
    - 14–24 GW of capacity is needed by 2050, depending on the season and the procurement of large nuclear.
    - 60–120 TWh of energy in needed by 2050, depending on the procurement of large nuclear.

Areas north of Sudbury will still need bulk transmission upgrades to accommodate large amounts of new generation.[31]

Energy simulations for the potential forecast indicate that, with the current resource portfolio and the renewal of non-emitting resources in the North, both the EWTE and FS interfaces will be heavily utilized to send energy into Northern Ontario by 2035. As a result, the NW zone is expected to import 2 TWh from the NE zone, while the NE zone will import 10.5 TWh from the Essa zone, as shown in Figure 10.1. This indicates there will be a significant amount of room behind these interfaces to locate resources to send energy to Southern Ontario. Applying the non-series compensated option, Table 10.1 through Table 10.5 show the levels of energy production and congestion that result, consistent with the methodology presented in 7.2.4. The series compensation option would result in lower levels of congestion.

[31] Large hydroelectric generation procurement is expected to require bulk transmission upgrades as per https://www.opg.com/documents/made-in-ontario-northern-hydroelectric-opportunities-pdf/

Figure 10.1| Estimate Flows on EWTE and FS Interfaces in 2035 for the Potential Forecast

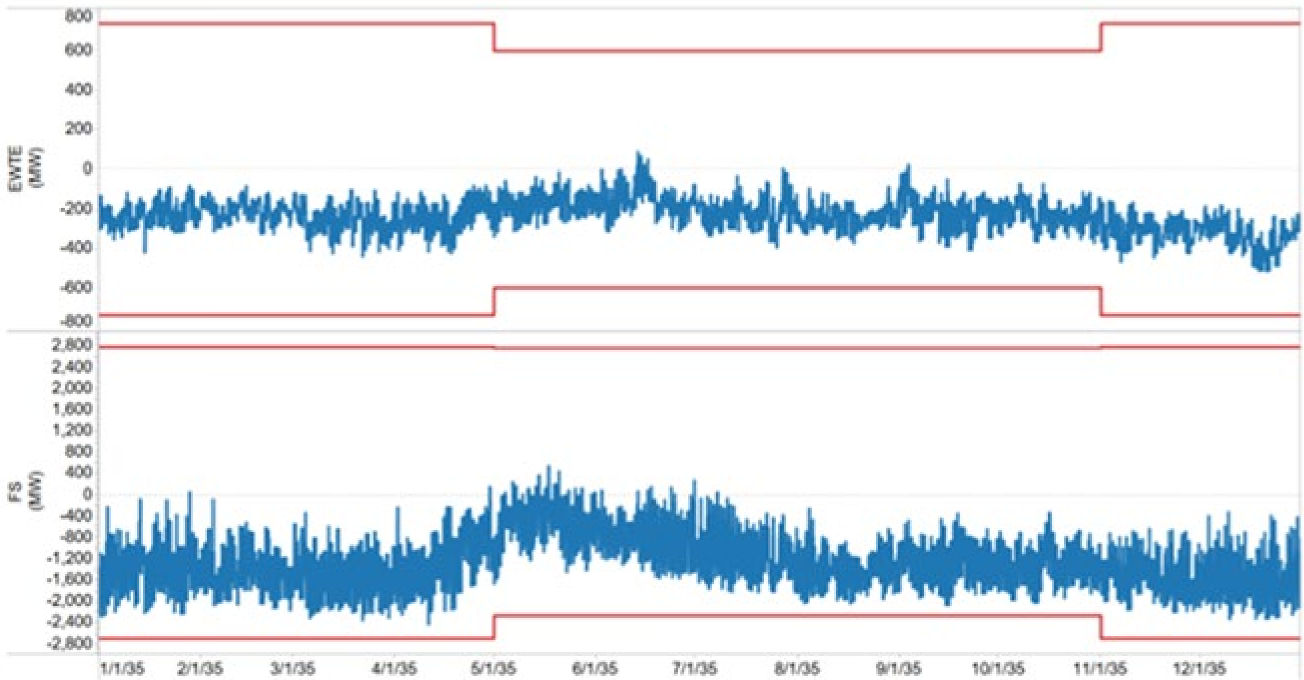


Table 10.1 | Energy and Congestion Analyis for Generation Portfolio A

—	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Total Energy produced in NE+NW (GWH)	2,897	2,462	2,774	2,689	3,115	2,570	2,540	2,278	2,331	2,677	2,366	2,622
Congestion (GWH)	0.94	0.0	0.3	14.7	26.5	0.0	2.2	0.0	0.5	0.0	0.0	2.7
Congestion (%)	0.03%	0.00%	0.01%	0.54%	0.84%	0.00%	0.09%	0.00%	0.02%	0.00%	0.00%	0.10%

Table 10.2 | Energy and Congestion Analyis for Generation Portfolio B

—	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Total Energy produced in NE+NW (GWH)	3,264	2,810	3,235	3,229	3,446	2,929	2,959	2,680	2,701	3,211	2,778	3,154
Congestion (GWH)	4.50	8.3	28.8	50.4	156.6	34.2	20.5	4.7	9.5	0.2	2.0	2.7
Congestion (%)	0.14%	0.27%	0.84%	1.51%	4.21%	1.08%	0.67%	0.16%	0.33%	0.01%	0.07%	0.08%

Table 10.3 | Energy and Congestion Analyis for Generation Portfolio C

—	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Total Energy produced in NE+NW (GWH)	3,204	2,671	3,035	2,971	3,278	2,715	2,689	2,425	2,520	3,012	2,644	3004
Congestion (GWH)	12.24	6.1	23.7	39.8	125.8	12.2	19.8	1.6	6.8	7.8	0.0	3.9
Congestion (%)	0.38%	0.23%	0.78%	1.32%	3.69%	0.45%	0.73%	0.06%	0.27%	0.26%	0.00%	0.13%

Table 10.4 | Energy and Congestion Analyis for Generation Portfolio D

—	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Total Energy produced in NE+NW (GWH)	3,241	2,719	3,126	3,077	3,352	2,843	2,851	2,601	2,621	3,082	2,673	3,023
Congestion (GWH)	16.59	11.9	51.5	80.7	189.5	50.3	53.2	14.9	18.4	30.8	1.1	5.0
Congestion (%)	0.51%	0.44%	1.62%	2.56%	5.35%	1.74%	1.83%	0.57%	0.70%	0.99%	0.04%	0.16%

Table 10.5 | Energy and Congestion Analyis for Generation Portfolio E

—	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Total Energy produced in NE+NW (GWH)	3,374	2,810	3,235	3,229	3,446	2,929	2,959	2,680	2,701	3,211	2,778	3,154
Congestion (GWH)	54.19	28.3	97.6	162.6	329.0	100.9	95.0	25.9	37.8	56.9	3.2	14.1
Congestion (%)	1.58%	1.00%	2.93%	4.79%	8.72%	3.33%	3.11%	0.96%	1.38%	1.74%	0.11%	0.44%

11 Additional Emerging Needs

11.1 Transmission Limitations North of Sudbury

Previous bulk plans have recommended additional transmission between Wawa TS and Porcupine TS (Timmins) to supply additional industrial load in the area. Potential new emerging industrial developments north of Sudbury would require additional bulk transmission after the FN Interface is reinforced. Therefore, a follow-up bulk plan should be developed to determine transmission options to support further economic development and enable non-emitting resources in the area North of Sudbury.

11.2 Transmission Limitations South of Barrie

Following system reinforcements on the FN interface, the CLANE and CLAS interfaces will become the limiting North-South Interface. Table 11.1 provides the transfer capabilities of the CLANE interface.

Table 11.1 | CLANE Transfer Capability

—	Summer (MW)	Winter (MW)
2031 System ALL I/S	2,900	3,400
2031 ExV O/S[32]	1,600	1,700

When one of E510V or E511V is out of service, the CLANE interface is limited by thermal ratings on E8V/E9V between Orangeville TS and Everett[33] Jct., resulting in a loss of the companion 500 kV circuit. When the transfer capabilities shown in Table 11.1 are combined with the existing supply and demand, as per Section 5 and Section 4.2, respectively, the needs on the CLANE interface are as shown in Table 11.2. It is important to note that the needs are once again driven by overnight demand, due to reduced hydroelectric generation north of the CLANE interface, as shown by the comparison of Figure 11.1 and Figure 11.2. The transmission security analysis concluded that a need would arise, and the date and amount would depend on the following:

- The amount of non-committed industrial load growth and the speed at which these facilities connect, as shown when comparing the firm and potential load growth scenarios.

[32] E510V spent 214 days O/S in 2024 due to failed gas insulated switchgear equipment at Claireville TS.

[33] The South Georgian Bay-Muskoka RIP Dec. 2022 indicates this section is to be replaced with like for like.

- The amount and dates of thermal generation retirements north of the FN and CLANE interfaces.

Similar to the case of the Flow North Interface case an energy need will become present due to the large capacity need occurring at all hours.

Table 11.2 | Needs North of the CLANE Interface

—	Firm Demand Scenario Need	Potential Growth Scenario Need
System ALL I/S	Overnight needs arise starting in 2031, following the potential retirement of thermal resources north of the CLANE interface. They then rise sharply to ~1,000 MW in 2036 with further potential retirements, and continue increasing year over year to ~2300 MW by 2050.	Overnight needs start to arise in 2028 with the potential retirement of thermal resources north of the CLANE interface. They then rise sharply to ~1,700 MW in 2036 following additional potential thermal unit retirements with a year over year increase to ~3,200 MW by 2050.
ExV O/S	Marginal overnight needs start to arise in 2025 with a significant increase to 1,500 MW by 2031 following the potential retirement of thermal resources north of the CLANE interface. They then increase year over year to ~3,700 MW by 2050.	Marginal overnight needs start to arise in 2024 with a significant increase to 2,300 MW by 2031 following the potential retirement of thermal resources north of the CLANE interface. They then increasing year over year to ~4,600 MW by 2050.

Figure 11.1 | Load Meeting Capability North of the CLANE Interface for the Winter Months

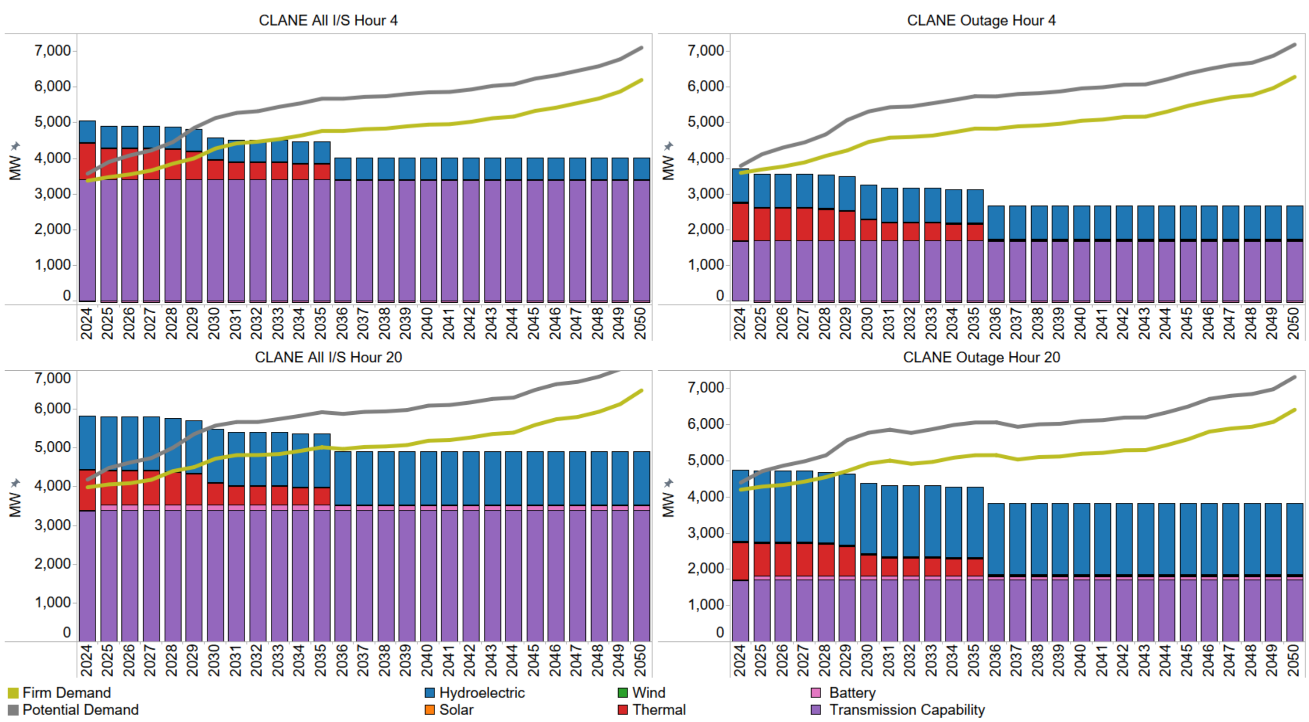
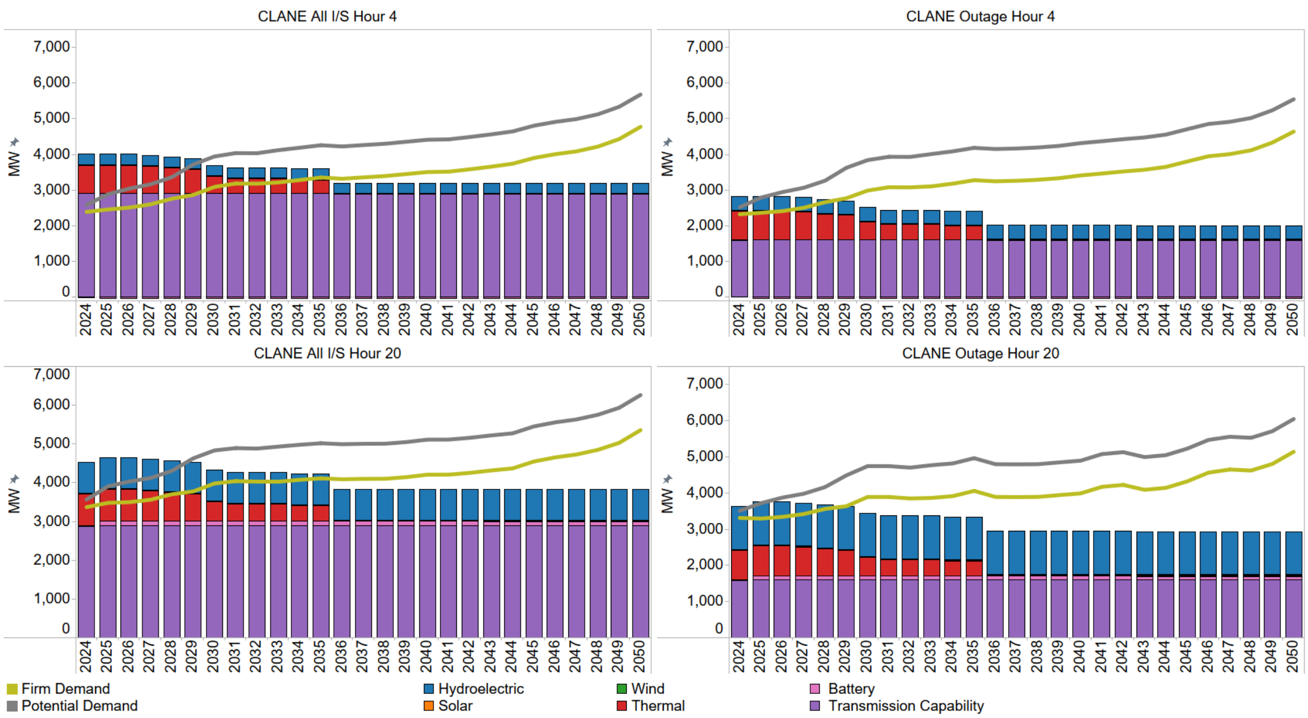


Figure 11.2| Load Meeting Capability North of the CLANE Interface for the Summer Months



Therefore, the IESO recommends replacing end-of-life conductors on E8V/E9V with higher-ampacity conductors, which would provide up to an additional 400 MW of transfer capability.

Due to the CLANE/CLAS interfaces having several interdependencies with the South Central Bulk Study and the York IRRP, it is therefore recommended to assess longer-term needs on this interface via the South Central Bulk Study.

12 Recommended Solution

Based on the assessments and evaluations described throughout this document, this Plan recommends building a new single circuit 500 kV transmission line between Essa TS and Hanmer TS to enable both demand growth and resource procurement in Northern Ontario, while maintaining system reliability. The specifications of the new transmission line include:

- A targeted in-service date of 2032
- Thermal ratings equivalent to those of X503E
- A shunt line reactor to be installed at Hanmer TS, of similar size to R1 and R2 at Hanmer TS
- A series capacitor with similar characteristics to the existing series capacitors on X503E and X504E
- Station terminations consistent with the diagrams shown in Appendix B

In June 2025, the Government of Ontario released *Energy for Generations: Ontario's Integrated Plan to Power the Strongest Economy in the G7*. The plan included an announcement to advance the Barrie to Sudbury Transmission Line, a new single circuit 500 kV line between Essa TS (Barrie) and Hanmer TS (Sudbury), including any associated station facilities, targeted to be in-service by 2032. It further outlined an intention to consult on a proposal to direct the OEB to designate Hydro One to develop the line, and to declare this line a priority to ensure it is built on time. Further to an IESO recommendation to initiate early development work on a second 500 kV line between Essa TS and Hanmer TS, the plan also outlines an intention to consult on designating Hydro One as the transmitter for this line, to ensure they can undertake early development work.[34]

Construction of the new transmission line will require modifications to remedial action schemes that monitor the existing 500 kV circuits (X503E and X504E). There are currently three contingency-based schemes that monitor the status of X503E and X504E and they would require modification to monitor the status of the new circuit if they were to be maintained in their current form:

- Hanmer Reactor/Capacitor Switching Scheme, located at Hanmer TS
- Essa Reactor Switching Scheme, located at Essa TS
- The Moose River Generation Rejection Scheme, located at Pinard TS

It is recommended that the first two schemes be considered for conversion to a voltage-based scheme to simplify operations, and the third scheme be reviewed to determine its ongoing need.

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[34] https://www.ontario.ca/files/2025-07/mem-energy-for-generations-en-2025-07-18.pdf

This set of actions will accommodate the Firm Demand Forecast Scenario up to 2048 and the Potential Growth Forecast Scenario up to 2030. Longer-term actions will be needed to support higher demand growth scenarios and will be highly dependent on how procurement of new supply resources unfold. Therefore, preserving transmission options by beginning early development work on a second new single circuit 500 kV transmission line between Essa TS and Hanmer TS is recommended.

In parallel, the IESO will explore opportunities to site new supply resources in Northern Ontario. Given that needs are driven by overnight periods, where peaking hydroelectric generation is offline, siting new supply resources with an emphasis on resource types that are not energy-limited is essential. There are significant opportunities to utilize the 230 kV system west of Sudbury, given the nearly 1,500 km of recent transmission circuit buildouts, as this would defer potential future transmission needs west of Sudbury should additional demand be sited in these regions. An additional 400 MW of capacity would result in an ability to meet the Potential Growth Forecast Scenario up to 2040.

13 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 Indigenous communities, market participants, stakeholders, communities, customers, and the general public, to be considered in the development of the Plan. This engagement helps lay the foundation for the regional planning process by informing its decision-making.

The IESO has developed and is transitioning to a formalized process for bulk system planning to enhance transparency and opportunities for purposeful engagement and input. As part of that work, defining how communities and stakeholders can participate in the electricity planning process and be kept informed has been identified as a critical component of the process design. Providing opportunities for input in the transmission planning process enables the views and preferences of communities and stakeholders to be considered in the development of the plan and helps lay the foundation for successful implementation. The IESO has endeavored to encompass those principles throughout the Northern Ontario Bulk Plan work. This section outlines the engagement principles as well as the activities undertaken to date for this Bulk Plan.

13.1 Engagement Principles

The IESO's External Relations Engagement Framework is built on a series of key principles that respond to the needs of the electricity sector, communities and the broader economy. These principles ensure that diverse and unique perspectives are valued in the IESO's processes and decision-making. We are committed to engaging with purpose with external audiences to foster trust and build understanding as the energy transition continues.

Figure 13.1| The IESO's Engagement Principles

13.2 Engagement Approach

To ensure that the bulk plan reflects the needs of Indigenous communities, community members, customers, and interested stakeholders, engagement involved:

- Leveraging the Bulk Planning Initiatives and dedicated engagement webpage on the IESO website to post updated information, engagement opportunities, meeting materials, input received and IESO responses to the feedback;
- Regular communication with communities, stakeholders and interested parties through email and IESO weekly Bulletin;
- Public webinars; and
- Targeted outreach throughout plan development with Indigenous communities, rights-holders, municipalities, customers, and those with an identified interest in northeast Ontario electricity issues.

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

- Scope
- Electricity demand forecast
- Identified needs
- Options evaluation
- Draft recommendations

The webinars received strong participation, with Broad-representation of stakeholders and municipal and Indigenous community representatives in attendance and submitting written feedback during the specified comment period.

Comments received during this engagement focused on the following major themes:

- Consideration of non-wires solutions, including large-scale solar, storage, biomass, existing generation facilities, and distributed energy resources
- Support for transmission reinforcements
- The importance of access to additional information to ensure transparency in the planning process and recommendations

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

All background information, including engagement meeting presentations, recorded webinars, detailed feedback submissions, and responses to comments received, are available on the IESO's Northern Ontario Bulk Planning engagement webpage.

13.3 Bringing Communities to the Table

The IESO held targeted meetings with key municipalities in the Plan area to share preliminary options, answer questions, and understand community perspectives.

13.4 Engaging with Indigenous Communities

The IESO remains committed to ongoing, effective dialogue with Indigenous communities to help shape long-term planning across Ontario. To raise awareness about the development of this Bulk Plan in the Northwest and provide opportunities for input, the IESO invited Indigenous communities that may be potentially impacted or may have an interest based on treaty territory, traditional territory or traditional land use to participate in engagement initiatives, including webinars that were held on June 19, 2024, July 10, 2024, September 24, 2024, and November 10, 2024.

The following First Nations communities were invited to participate in engagement activities, including webinars:

- Animakee Wa Zhing No. 37
- Animbiigoo Zaagi'igan Anishinaabek
- Anishinaabeg of Naongashiing (Big Island)
- Anishinabe of Wauzhushk Onigum
- Aroland
- Asubpeeschoseewagong First Nation
- Bearskin Lake
- Big Grassy River (Mishkosiminiziibiing)
- Biigtigong Nishnaabeg
- Biinjitiwaabik Zaaging Anishinaabek
- Bingwi Neyaashi Anishinaabek
- Cat Lake
- Constance Lake
- Deer Lake
- Eabametoong
- Eagle Lake
- Fort Severn
- Gakijiwanong Anishinaabe Nation
- Ginoogaming First Nation
- Gull Bay First Nation

- Iskatewizaagegan No. 39
- Kasabonika Lake
- Keewaywin
- Kiashke Zaaging Anishinaabek
- Kingfisher Lake
- Kitchenuhmaykoosib Inninuwug
- Koocheching First Nation
- Lac des Mille Lacs
- Lac Seul
- Long Lake No. 58
- Marten Falls
- McDowell Lake
- Michipicoten
- Mishkeegogamang
- Missanabie Cree
- Muskrat Dam Lake
- Namaygoosisagagun
- Naotkamegwanning
- Neskantaga
- Netmizaaggamig Nishnaabeg (Pic Mobert)
- Nibinamik
- Niisaachewan Anishinaabe Nation
- North Caribou Lake
- North Spirit Lake
- Northwest Angle No. 33
- Ojibway Nation of Saugeen
- Ojibways of Onigaming
- Pays Plat
- Pikangikum
- Poplar Hill
- Rainy River

- Sachigo Lake
- Sandy Lake
- Shoal Lake No. 40
- Slate Falls
- Wabaseemoong
- Wabauskang
- Wabigoon Lake
- Wapekeka
- Washagamis Bay (Obashkaandagaang)
- Wawakapewin
- Webequie
- Weenusk
- Whitesand
- Whitewater Lake
- Wunnumin Lake

The following Tribal Councils and Provincial Territorial Organizations (PTOs) were invited to participate in engagement activities, including webinars:

- Anishinabek Nation, Union of Ontario Indians
- Chiefs of Ontario
- Grand Council Treaty #3
- Independent First Nations Alliance (IFNA)
- Keewaytinook Okimakanak/Northern Chiefs Council
- Matawa First Nations Management
- Matawa First Nations Tribal Council
- Nishnawbe Aski Nation
- Shibogama First Nations Council
- Windigo First Nations Council

The following Métis communities were invited to participate in engagement activities, including webinars:

- Métis Nation of Ontario

- Red Sky Independent Métis Nation

13.4.1 Indigenous Participation and Engagement in Transmission Development

By conducting bulk planning, the IESO determines the most reliable and cost-effective option after it has engaged with Indigenous communities and stakeholders and publishes those recommendations in the applicable bulk planning report. Where the IESO determines that the recommended solutions require immediate action, the IESO may provide those recommendations ahead of the publication of a planning report, such as through a hand-off letter to the lead local transmitter in the region, for example.

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, with any approval including steps to avoid or mitigate impacts to said rights. MECP oversees the consultation process generally but may delegate the procedural aspects of consultation to the proponent. 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 on ways to enable participation in these projects.

14 Reference Documents

Table 14.1 | Reference Documents

Document Name	Document ID
Ontario Resource and Transmission Assessment Criteria (ORTAC)	IMO_REQ_0041
Transmission System Planning Performance Requirements	NERC TPL-001-5
Regional Reliability Reference Directory # 1 Design and Operation of the Bulk Power System	NPCC Directory #1
Remedial Action Schemes	NERC PRC-012-2
Regional Reliability Reference Directory # 7 Remedial Action Schemes	NPCC Directory #7
Annual Planning Outlook Ontario’s electricity system needs: 2025–2050 March 2024	—
Integrated Regional Resource Plan Parry Sound/Muskoka May 2022	—
Integrated Regional Resource Plan Barrie/Innisfil May 2022	—
Integrated Regional Resource Plan East Lake Superior Region April 2021	—
Integrated Regional Resource Plan East Lake Superior Region April 2021	—
Integrated Regional Resource Plan North & East of Sudbury April 2023	—
Integrated Regional Resource Plan Northwest Region January 2023	—
Need for Northeast Bulk System Reinforcement October 2022	—
Bulk System Reactive Requirements in Northern Ontario December 2023	—
Preliminary Connection Guidance for the Long-Term 2 RFP – Energy Stream September 2024	—

Appendix A
Planned Transmission Projects

Table A.1 | Planned Transmission Projects

Transmission Project	Estimated In-service Date
K4 Reconductoring	2024
X29S (X25S Unbundling)	2024
A30L+A31L (New 230 kV double circuit Lakehead TS and Mackenzie TS)	2025
NW Reactors (2x 40Mvar @ Mackenzie TS, 1 x 40Mvar @ Lakehead TS)	2025
Mackenzie T3 replacement + New load station on A3M (Replaces Moose Lake TS)	2025
Tagona West TS	2025
M2W unbundling	2025
Porcupine TS 500/115 kV autotransformer replacements	2025/2026
Thirdline T2 Replacement	2025/2026
D32A (New 230 kV circuit between Mackenzie TS x Dryden TS)	2026
Sault 3 reconductoring	2026
Otto Holden TS Station Rebuild	2026
Wawa TS Autotransformer Replacements	2027
Essa T3 Autotransformer Replacement	2027
Algoma and Mississagi STATCOM (± 100Mvar each)	2029
New Lakehead STATCOM	2025
P23G/P24G (North Shore Link - New 230 kV double circuit between Mississagi TS and Thirdline TS)	2029
X505P (Northeast Power Line - New 500 kV circuit between Hanmer TS and Mississagi TS + 100 Mvar Reactor)	2029
P503W (New 230 kV circuit between Porcupine TS and Wawa TS)	2030

Note: like for similar circuit reconductoring is also included.

Appendix B
Proposed Physical Arrangements

Note: all nomenclature is subject to change.

Figure B.1 | Existing Physical Layout at Hanmer TS

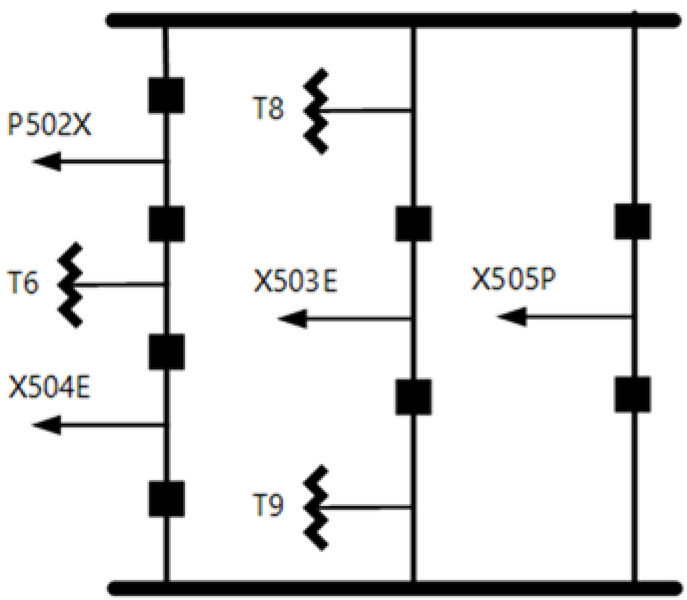


Figure B.2 | Recomended Physical Layout at Hanmer TS

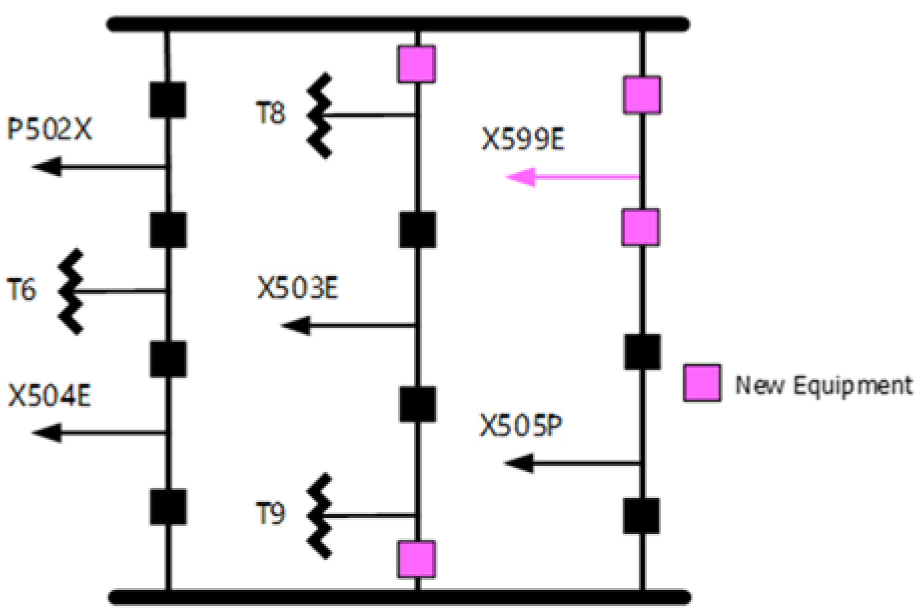


Figure B.3| Existing Physical Layout at Essa TS

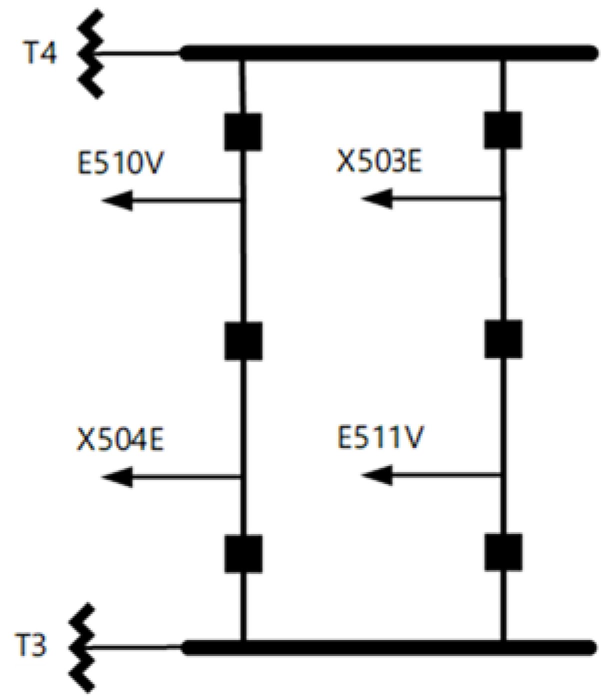
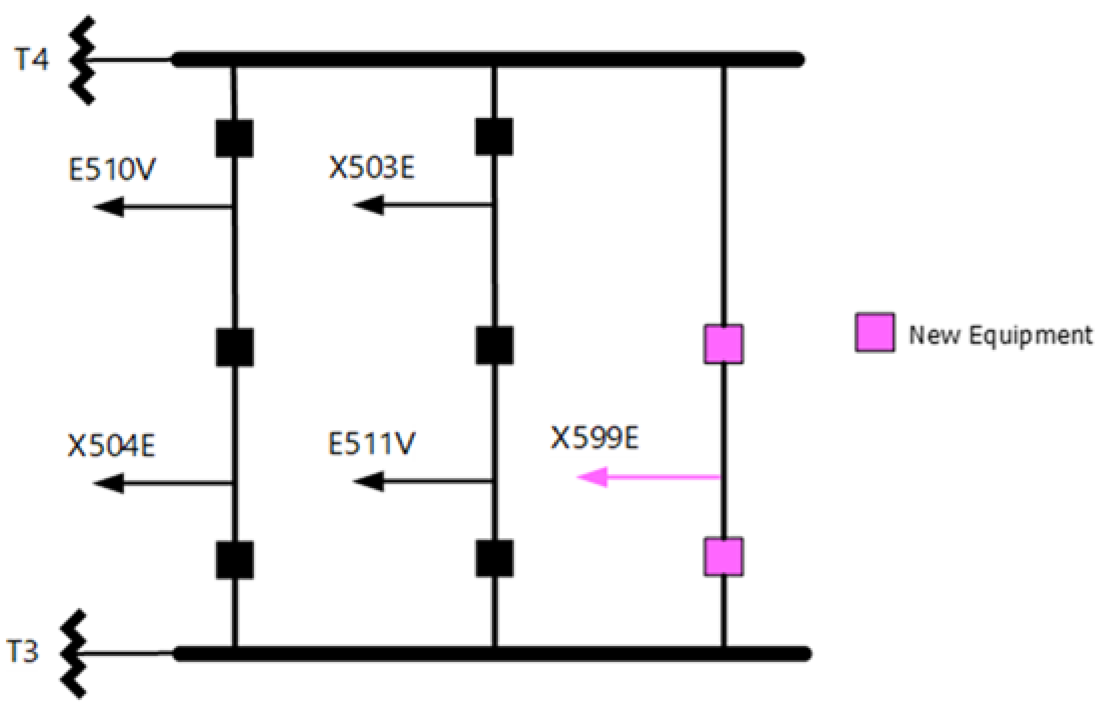


Figure B.4| Recomended Physical Layout at Essa TS



Appendix C
Economic Analysis 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 2024 CAD.
- The CAD/US exchange rate was assumed to be 1.34 for the study period.
- The NPV analysis was conducted using a 4% real social discount rate.
- An annual inflation rate of 2% is assumed.
- The life of the transmission line was assumed to be 70 years, and the life of NWA resources is based on National Renewable Energy Laboratory (NREL) 2024 Annual Technology Baseline (ATB) workbook. Costs of asset replacement were included where necessary to ensure the same NPV study period.
- Levelized costs for all NWA resources are based on overnight capital costs from the 2024 NREL ATB workbook.
- 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.